POWER

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HELPFUL HINTS

Money Talks

A WELL-KNOWN American chief engineer has succeeded in his profession because of his ability to quickly convince his superiors that he is right. He finds that the best way to convince is to talk in terms of the almighty dollar. When he says to the owner, "You are actually burning up every day in those furnaces a ten-dollar bill that could as well be saved," the owner feels in his pocket for the escaped ten-spot. The engineer soon gets the stokers he wants.

He wants to increase the size of the plant and thereby advance his salary, so he says to the owner, "I'll work for you for nothing next year if you will give me your exhaust steam." The owner's interest is again aroused, the exhaust steam is made to do good work, and the owner saves MORE than the engineer's salary.

"It's strange, isn't it," he remarked one day as the owner was on an excursion through the plant, "that our oil costs more after we have used it than it costs to buy it." The owner was stumped. He had never heard of such a thing, so he asked for an explanation. The engineer did himself proud in explaining the nuisance of oil in boilers. The filter he wanted was therefore quickly installed.

He always attacks his needs in an original way. He takes the owner by surprise whenever he can, so as to get due consideration. When he wanted a feed-water heater he said, "I need another helper. Can I have one? He won't cost anything." This opened the way to his carefully planned argument. The feed-water heater is installed.

Owners, managers, superintendents and bosses are all human beings and they enjoy a change in method of attack. Don't hammer away for what you want in the same way all the time.

Money talks, so why not give it a chance to be heard?

Contributed by W. F. SCHAPHORST, *New York City*

City and State Power Plants at Columbus, Ohio

By Thomas Wilson

SYNOPSIS—The city of Columbus generates electric energy for its street lighting and for sale to private consumers. It also owns the plant in which grease and liquid are removed from the city garbage. The tankage remaining is dried and sold for fertilizer. The city owns and operates a plant in which river water is filtered, chemically treated and then pumped into the water-works system. The power equipment in these plants is considered in this article, as is also that of the Ohio penitentiary and the state university, both of which are in Columbus.

From the standpoint of industrial development Columbus, Ohio, ranks among the leading cities of the country. It has more than 800 plants manufacturing annually $85,000,000 worth of products. Although, because of the low rates, much of the power for manufacturing is purchased, still there are a number of power plants that should be included on the visiting list. Among these are the city and state institution plants described in the following paragraphs.

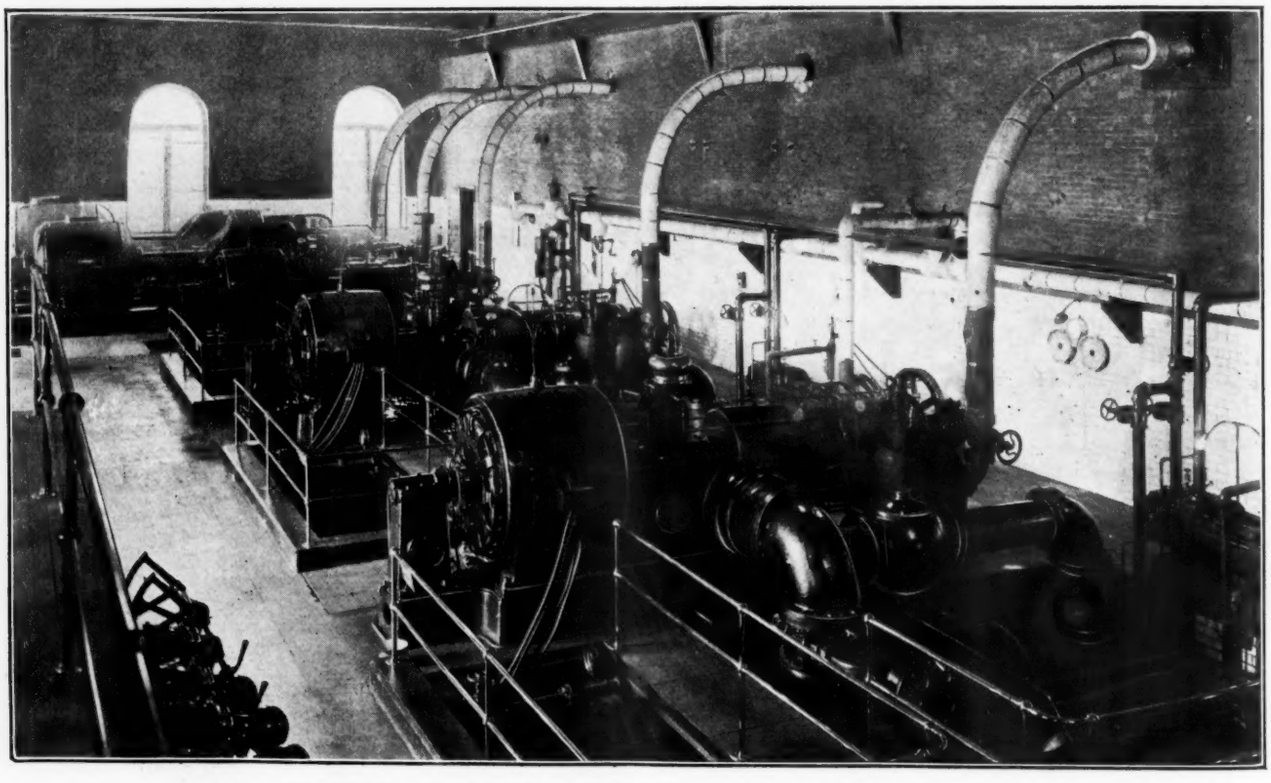


FIG. 1. TURBINES AT MUNICIPAL LIGHT PLANT; 400-KW. UNITS IN FOREGROUND

Municipal Electric-Light Plant

The present municipal plant on West Spring St. began operation in 1900 with three 400-kw. two-phase 2200-volt 3600-r.p.m. turbo-generator sets. There have since been added one 1000-kw. and one 2000-kw. 1800-r.p.m. units. The turbines, Fig. 1, operate on 160-lb. steam pressure and 100 deg. of superheat. They are equipped with surface condensers, the smaller condensers having 4.8 sq.ft. and those for the two large turbines 3.2 sq.ft. of surface per kilowatt of generator rating. Cooling water is obtained from the nearby river, and the vacuum carried averages 28 in.

The boiler plant has six 300-hp. water-tube units set in batteries of two. The boilers are equipped with superheaters, economizers and Dutch-oven furnaces with top-feed stokers. A draft of $\frac{3}{10}$ in. over the fire is maintained by a brick-lined steel stack 260 ft. high. An open heater and the economizer raise the feed-water temperature to 210 deg. F. The makeup to the condensate is drawn from the city mains.

The plant generates current for street lighting, for municipal buildings and for commercial purposes. The central part of the city is illuminated by five-light, ornamental cluster standards and the outlying districts by arc lamps. The standards cover 12 mi., and the arc lamps, with a number of incandescents, 215 mi. of street.

During the winter the peak runs up to 2900 kw. The day load is mostly power and averages about 1200 kw. for the whole year. The peak from 4 to 9 p.m. during the winter requires the two larger units. The 2000-kw. machine carries the summer peak and is run 24 hr. a day and 6 days a week. On Sunday one 400-kw. machine is used.

In 1914 the municipal plant generated 8,321,217 kw.-hr. of electrical energy. About three-quarters of this was used for street lighting and the rest was sold to private consumers. The average cost of coal was $1.392 per ton, and as 4.57 lb. of coal were burned per unit of energy, the fuel cost was 0.318c. per kw.-hr. The total cost of energy during the year averaged 2.110c. per kw.-hr. This figure is the sum of generating, transmission and

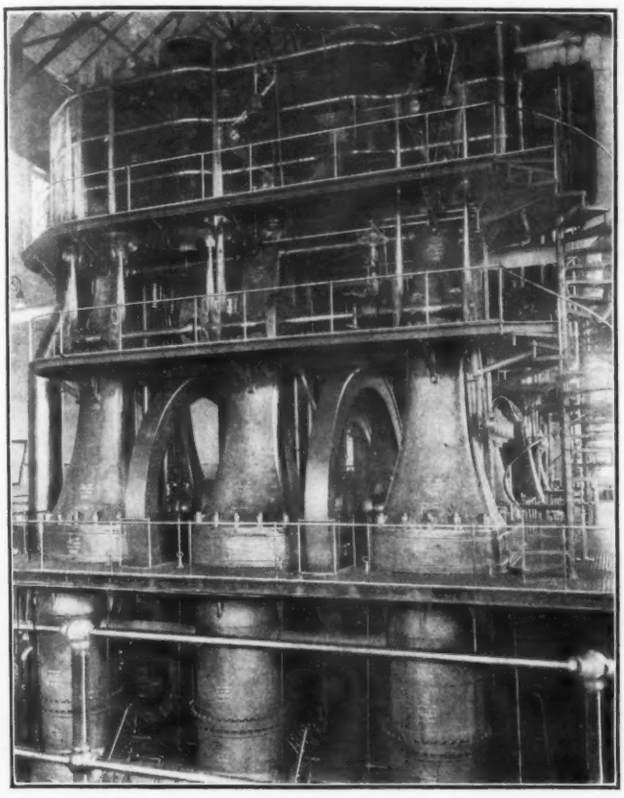


FIG. 2. PUMPING ENGINE AT WATER-WORKS

administration costs, which were respectively 0.544c., 0.408c. and 1.158c. The revenue derived from the sale of 2,344,570 kw.-hr. was $42,555.56, or an average of 1.815c. per kw.-hr. Energy is sold at rates varying from 3c. for users of 1000 kw.-hr. or less to 1.6c. for 12,000 kw.-hr. or more.

Scioto River Pumping Station and Water Purification Works

Two vertical triple-expansion engines, Fig. 2, each of 20,000,000 gal. per 24 hr. capacity, pump filtered water to the city against an average head of 205 ft. These machines develop 170,000,000 ft.-lb. per 1000 lb. of dry steam. A third unit of the same type, with a capacity of 25,000,000 gal. and a duty of 175,000,000 ft.-lb. per 1000 lb. of dry steam, is now being erected. There is also a 5,000,000-gal. motor-driven centrifugal booster pump.

Raw water is pumped from the Scioto River to the purification works by three 20,000,000-gal. centrifugal pumps, two driven by compound engines and the third by a motor. The 30-ft. dam built across the river 4½ mi. above the purifying and softening works forms a storage reservoir 5.8 mi. long and 500 ft. average width, with a capacity of 1,720,000,000 gal.

Primarily, the purification plant consists of a lime saturator in which the chemical reaction begins; two baffled mixing tanks; a six-compartment settling basin, of 15,000,000 gal. capacity, in which the greater part of the turbidity and the precipitated materials are removed by sedimentation; ten mechanical filter units, each with a net filtering area of 1089 sq.ft. and a capacity of 30,000,000 gal. per 24 hr.; and a covered filtered water reservoir holding 10,000,000 gal. There are also a storage house for chemicals and a headhouse for the equipment that dissolves and feeds the lime, soda ash and coagulant into the water. The chemical and bacteriological laboratories are also in this headhouse.

The alum plant recently put into operation is the first of its kind, and the Columbus Water-Works is the first pumping station to make its own alum for purifying water. The cost for making alum in this plant is about $10 per ton, which may be compared to $17, the average price paid by the city during the last few years. The plant cost $12,000, and as it will save about $6000 annually it should pay for itself in two years.

The four 300-hp. water-tube boilers are hand-fired and carry a pressure of 150 lb. gage. The Hocking run-of-mine coal is burned.

During 1914 the average total hardness of the water was 297 parts per 1,000,000, whereas the soft, filtered water had only 79 parts, a reduction of 73.4 per cent.

Municipal Garbage-Reduction Plant

The garbage, after delivery in tight steel cars into the unloading building, is dumped and sorted while being shoveled on a scraper conveyor and is thus carried to the top of the third story of the reduction building above

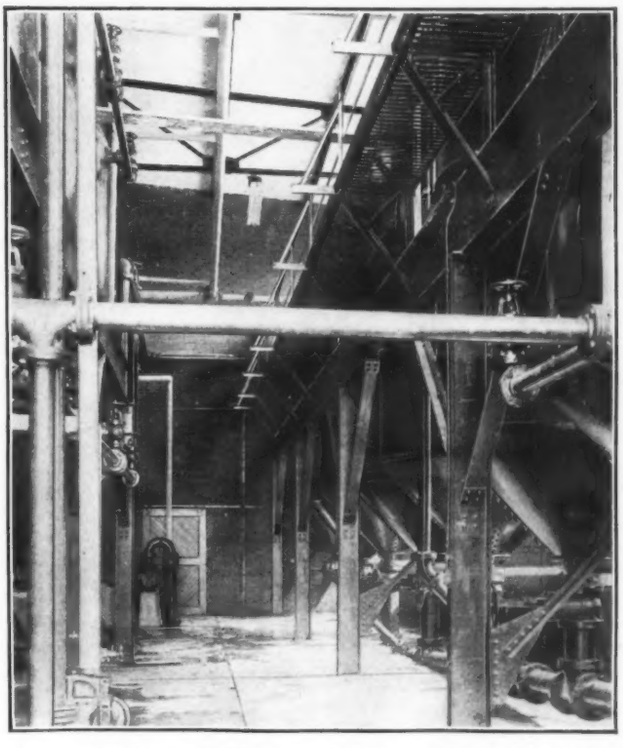


FIG. 3. GREASE-SEPARATING TANKS AT CITY GARBAGE REDUCTION PLANT

the digesters. Eight of these machines, each of about 10 tons capacity, cook the garbage with steam at 60-lb. pressure. The steam and gas from the digesters are led to a jet condenser supplied with cold water. The condensers discharge to a hotwell, from which a vent carries the gases to the boiler fires, where the odors are destroyed.

After being cooked the charge falls by gravity into a receiving hopper, where a roller presses out the free liquor and grease. From the press the liquor and grease flow to two catchbasins, from where they are pumped into a battery of six separating tanks, Fig. 3, connected in series

fired. The tankage is fed in at the front through spouts from the second floor and when dried is discharged at the rear. Induced draft draws the hot gases through the two driers. One is used to dry the tankage as it comes from the roller presses and the other to redry the tankage after

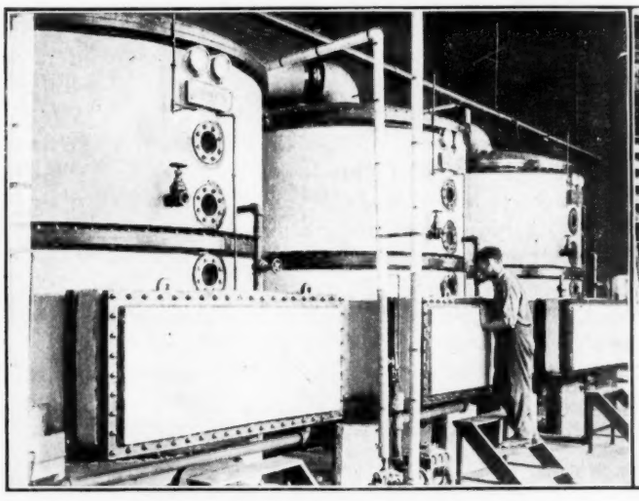


FIG. 4. PRESSES FOR SEPARATING LIQUID FROM COOKED GARBAGE

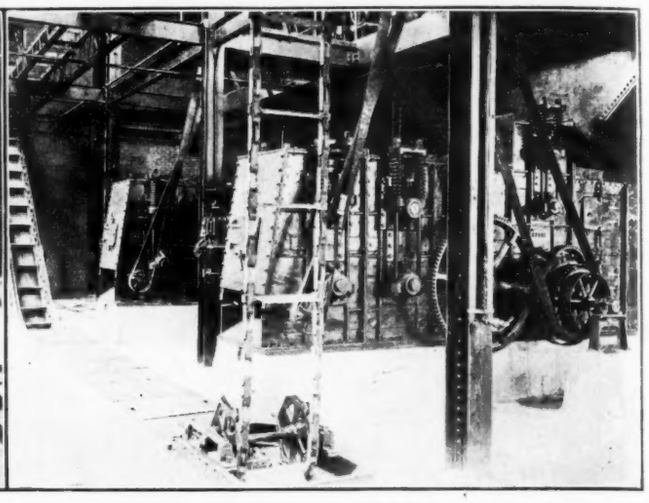


FIG. 5. TRIPLE-EFFECT EVAPORATOR FOR RECOVERING DISSOLVED SOLIDS

by nozzles near the top. The grease separates from the liquor by gravity, collects in the last separating tank, from which it is drained to treating tanks, and finally is run into four storage tanks.

The liquor from the presses, Fig. 4, carries more or less muck and silt in suspension. The muck settles to the bottom of the separating tank and the silt rises to the top of the water just below the grease. Both are drawn off by a ball-valve pump and discharged into a tank similar to the separating tank. The contents of this tank are placed in a screw press, from which the liquor flows to

it has been degreased and has the concentrated liquors from the evaporators added.

After the first drying process the tankage is conveyed to another building, discharged into a large storage hopper and fed through spouts into a percolator. This machine is of the horizontal cylindrical revolving type, with a capacity of about 10 tons of tankage per charge. After it is filled with material and sealed, gasoline is pumped into the percolator. The gasoline dissolves the grease, which is drawn off into distilling tanks. The gasoline in a vapor form is then driven off by steam heat, passes

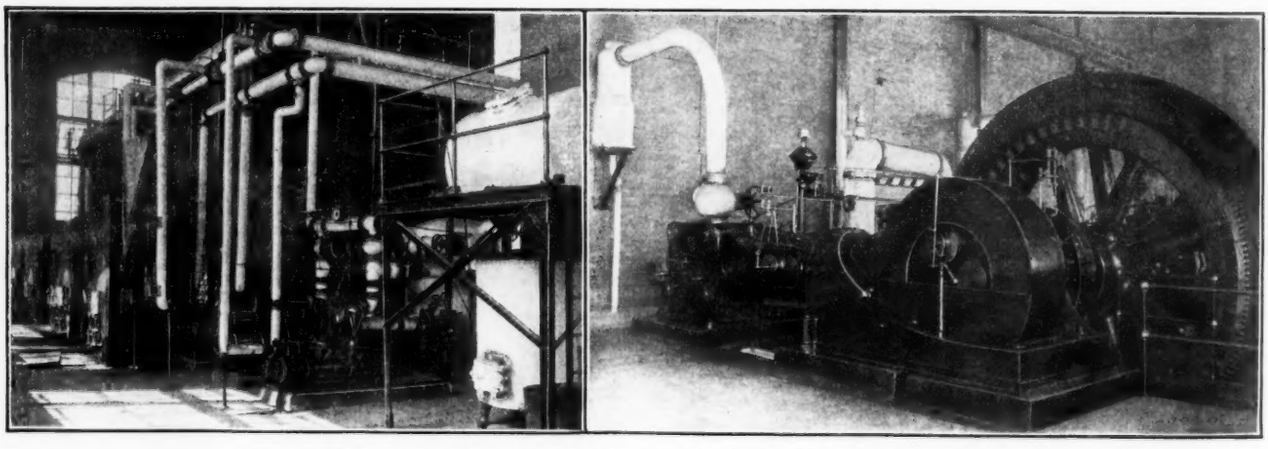


FIG. 6. BOILERS, PUMPS AND ENGINE AT STATE PENITENTIARY PLANT

catchbasins and the solids are carried by the conveyor to the drier room.

After the grease has been separated the water is drawn off into a large tank outside of the building. It then goes to a triple-effect evaporator, Fig. 5, in which the solids in solution are recovered. The vacuum is maintained by a condenser pump of the injection type.

Two revolving direct-heat driers 5 ft. in diameter by 30 ft. long are heated by coal-burning furnaces. One furnace has an underfeed stoker, while the other is hand-

to a condenser and finally to storage. The material is washed with gasoline three or four times, to prevent loss of grease. After the last wash live steam is passed through the material in the percolator to drive the gasoline through filters to the condenser, from which it is returned to storage.

The screened tankage is then mixed with the concentrated liquors or tank water recovered in the evaporators and passed through the second drier, so that all solids originally in the garbage, with the exception of grease,

are combined as a dry tankage. After the final drying the tankage is ground, screened and elevated to the storage room or loaded into cars for shipment as fertilizer.

Ohio Penitentiary Power Plant

The state penal institution, although not a desirable place to go under some circumstances, has many features of interest for visitors. There are 17 buildings, exclusive of the cell blocks, covering 23½ acres of ground. In them are made blankets, cloth, soap, shirts, and a variety of other products. The buildings are connected by a system of tunnels, through which pass the exhaust-steam, high-pressure steam, hot-water and return piping.

The power plant furnishes heat, light and power for the penitentiary buildings and electric current to other state institutions in the city. The 24-hr. load averages from 5000 to 7000 kw.-hr. Three-phase 60-cycle current generated at 465 volts is used in the penitentiary. For outside service the voltage is stepped up to 2500. Two 600-kw. cross-compound Corliss engine-driven units, Fig. 6, handle this load. Ordinarily one machine is sufficient, but occasionally the two are run in parallel.

The exhaust steam is used for heating the buildings by both direct and indirect vacuum systems. It also heats large quantities of water for bathing, and a lesser amount in the woolen mills for drying. Some exhaust steam is condensed for ice-making, the plant being equipped with a 15-ton vertical compressor, serving a 3½-ton ice tank and 7 tons of refrigeration in various storage rooms.

Four 350-hp. Sterling boilers, Fig. 6, supply steam at from 150 to 165 lb. pressure to the generating units, and at 65 to 85 lb. to the kitchen. Each boiler has a top feed stoker with a projected area of 76 sq.ft. A brick stack 207 ft. high and 9 ft. in diameter at the top supplies draft of 0.25 in. over the fire, 0.48 in. at the first baffle, 0.64 in. at the second baffle and 0.70 in. at the breaching. These intensities depend of course on the thickness of the fuel bed and the character of the coal.

Either Hocking Valley or West Virginia coal is burned. With the former an evaporation of about 6.5 lb. of water per pound of coal as fired is obtained and about 7.4 lb. per pound of combustible. The water evaporated with the West Virginia coal averages about 7.4 lb. per pound of coal as fired and 8.4 lb. per pound of combustible. Water for the plant taken from the Scioto River contains about 25 grains of incrusting solids per gallon and is low in sulphate and high in carbonate. A softening and filtering system has therefore been installed, consisting of duplex quartz filters, settling tanks and a heater. Caustic soda reduces the incrusting solids to 4 or 5 grains per gallon.

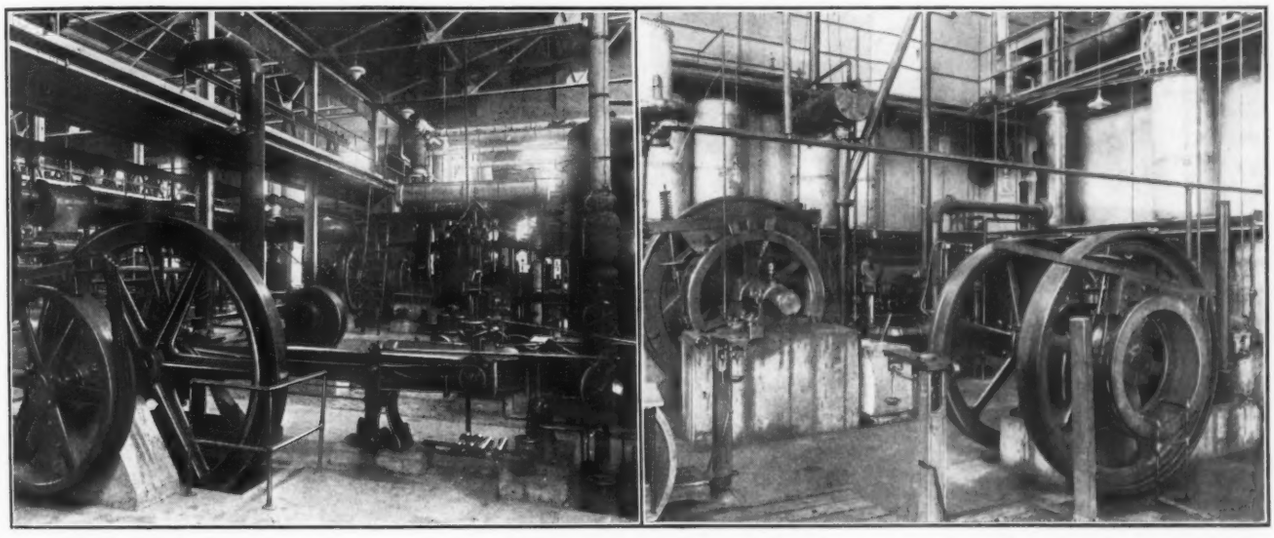
Engineering School Power Equipment

The Ohio State University has a diversified power plant and also a practical engineering laboratory. The equipment permits the student to experiment with prime movers of different types. The department of instruction is always glad to explain methods and equipment, so that a visit should be worth while.

The plant serves 30 buildings, the most distant being about 3000 ft. away. Heat, light and power are distributed through a system of tunnels. The peak load in winter runs up to 575 kw. Two-phase 1100-volt 60-cycle current is supplied by generators driven by a 300-kw. reaction turbine, a 400-kw. impulse-reaction turbine, a 125-kw. tandem compound engine and a 100-kw. gas engine. Usually one turbine carries the load, but a second turbine or a compound engine is used on the peak. In summer the turbines exhaust into the condensers, but in the heating season the steam first passes through two hot-water heaters, each with 100,000 sq.ft. of surface. A vacuum of from 15 to 16 in. is maintained on the turbines during the heating season.

The heating is partly by hot water and partly by live steam. The hot-water system serves 70,000 sq.ft. of radiation. The boiler pressure of 140 lb. is reduced to 30 lb. in the boiler house. Steam is transmitted at this pressure to the buildings and is there reduced to 1-lb. pressure for distribution. Fifteen buildings are thus heated by live steam. Most of the steam heating is hot blast, of which there is an equivalent of 150,000 sq.ft. of direct radiation.

In the boiler-room there are two 150-hp., two 300-hp., one 450-hp. and one 500-hp. water-tube boilers, totaling 1850 hp. Forced draft is supplied for the underfeed



FIGS. 7 AND 8. ENGINEERING LABORATORIES AT OHIO STATE UNIVERSITY

Fig. 7—Steam engine laboratory. Fig. 8—Gas engine laboratory

stokers, and a 200-ft. stack 9 ft. in diameter at the top provides the necessary draft for the top-feed stokers. The boilers are fed by turbine-driven, 4-stage centrifugal pumps.

The feed water is drawn from shallow surface wells and contains 38 grains of solids per gallon, 19 being sulphate of lime, 15 carbonate of lime and the rest magnesium, silicate and a trace of iron. Consequently a water softener with a capacity of 2000 gal. an hour is used. As the water passes from this apparatus it is 92 per cent. soft. It is delivered into a small lake which supplies the boiler-feed and the condenser circulating pumps. The cost of pumping and softening the water, including overhead charges, is about 9½c. for each 1000 gal.

The engineering laboratory building is divided into power transmission, hydraulic, steam-engine, gas-engine, locomotive, automobile and electrical laboratories and the boiler room. It also contains a recitation and a computing room, a museum and an amphitheater for demonstrations.

The most interesting apparatus in the steam-engine laboratory, Fig. 7, is the 4½&10x6-in. vertical tandem compound experimental engine designed by Prof. W. C. Magruder for instructional purposes. Each cylinder has an adjustable riding cut-off, and the unit can be used with or without the Stephenson link motion. The engine was designed for a working pressure of 150 lb. and a speed of 400 r.p.m. High-pressure steam can be admitted to each cylinder and exhausted separately. The high-pressure piston rod can be disconnected and only the low-pressure cylinder used. The low-pressure cylinder has double exhaust ports, so that when the clearance is increased on the head end by rings the effect may be investigated.

The largest unit in the gas-engine laboratory, Fig. 8, is a four-cycle, twin-tandem engine that may be adapted to run on either natural or producer gas. The latter is supplied by a combined up-draft and down-draft, 75-hp. producer, using Ohio coal. The laboratory has six different types of gas, gasoline and oil engines, affording an excellent opportunity for experimental work.

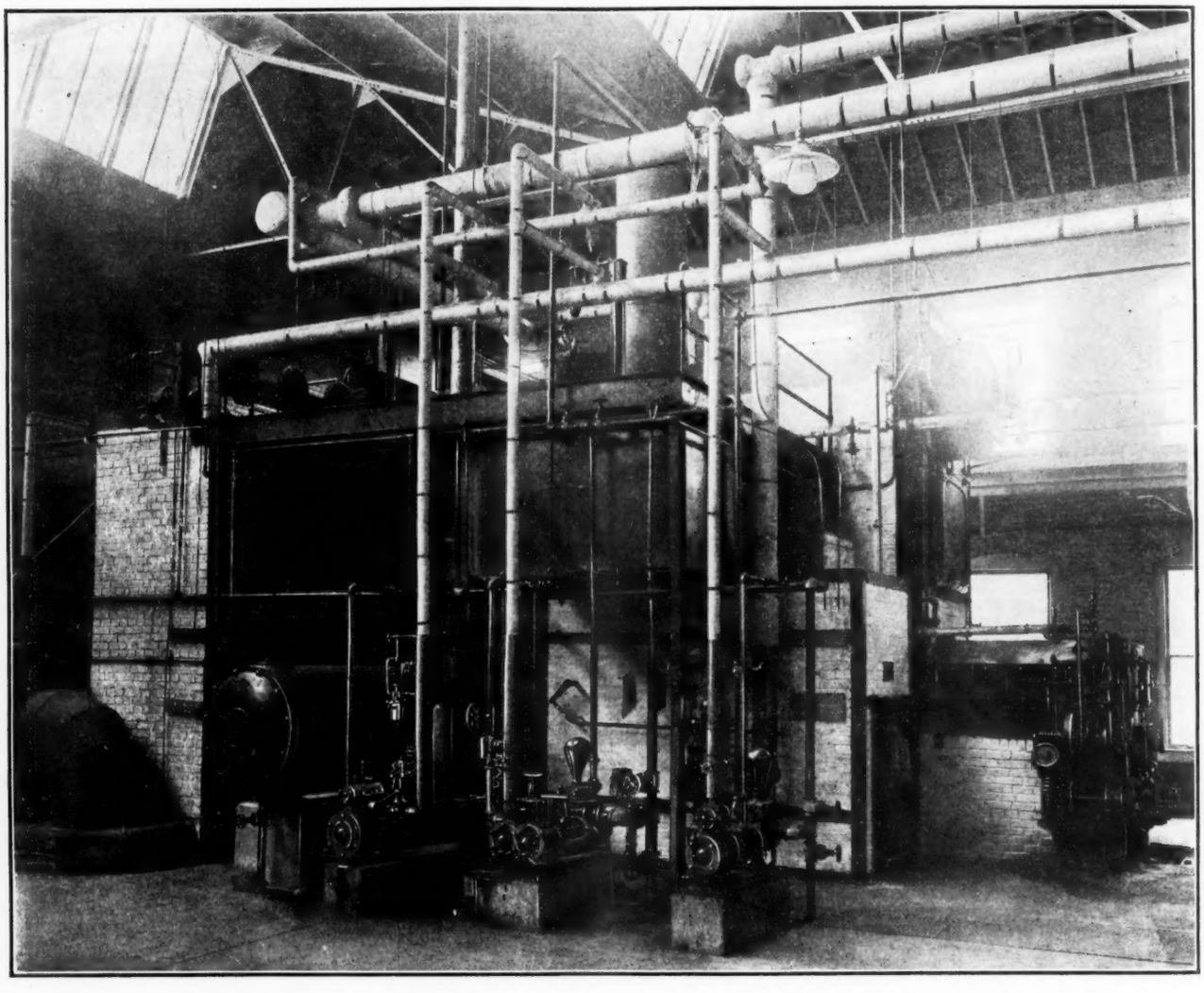


FIG. 9. ROBINSON EXPERIMENTAL BOILER, FEED-WATER PUMPS AND HEATERS

The 107-hp. Robinson experimental boiler, Fig. 9, of the water-tube type, is the most important apparatus in the boiler room. It is built for a pressure of 200 lb., has a top-feed automatic stoker in front and is equipped for hand-firing at the back. Either furnace may be used by simply laying up a firebrick wall. There is also an economizer, an air heater and induced-draft and forced-draft fans. In the foreground of Fig. 9 are the feed-water heaters and the feed pumps. The platform above the pumps supports the weighing and collecting tank.

Unity Cylinder Ratio for Dry-Vacuum Pumps

By R. S. Howard

It has been the custom of some builders of dry-vacuum pumps to employ a two-stage unit with the seemingly peculiar feature of having the two cylinders the same size. At first thought there would appear to be no good reason for this, any more than for making a compound steam engine with the low-pressure cylinder the same size as the high-pressure. In the case of the steam engine it is difficult to see how any compounding could be accomplished with such an arrangement, and in the case of an air compressor (which is just what a dry-vacuum pump is) it would at first appear equally ineffective.

In the compound vacuum pump the effect of the cylinder clearance is so marked that this feature alone serves to create an actual effective cylinder ratio greater than unity, even with equal cylinder sizes, resulting in an actual compound compression (or exhaustion) the sole object of which is to increase the volumetric efficiency, or air output.

It is well appreciated that any cylinder must have a certain amount of clearance volume, or dead space through which the piston does not travel. This is made up of the necessary clearance between piston and cylinder head, which is made as small as is consistent with safety, and also the cavities and ports leading to inlet and discharge valves. The effect of this waste space is to trap some of the air as it is compressed, instead of allowing it to escape through the discharge valves. Then on the return, or suction, stroke of the piston this trapped air reëxpands, helping to move the piston, it is true, but also helping to occupy space which should be taken up by incoming air. Whatever clearance air is thus allowed to expand keeps out just that much new air and so cuts down the intake and output of the pump. The greater the compression, the greater the amount of air that will be squeezed into this clearance space and the greater the amount of reëxpansion on suction strokes to keep out the incoming air. Therefore, as the number of compressions increases, the less will be the relative amount of air delivered by the pump, and as the compressions increase rapidly with higher vacuum (26-in. vacuum is about 7¾ compressions, 28-in. vacuum is 15¾ compressions, while 29-in. vacuum is nearly 33 compressions), it follows that the volumetric efficiency of the cylinder decreases rapidly as the vacuum becomes higher.

Now, consider a compound vacuum pump that has a cylinder ratio of 2 to 1; that is, the low-pressure cylinder has twice the piston displacement volume of the high-pressure. It is evident that, clearance effects neglected, the low-pressure cylinder will deliver air to the high-pressure cylinder at some pressure intermediate between that of the vacuum from which it is pumping and the atmosphere or final-discharge pressure. As a matter of fact, with a cylinder ratio of 2 the intermediate pressure will be somewhere around 2¼ times the absolute vacuum pressure, depending upon the amount of radiation surface provided between cylinders. If there is an intercooler between and the air is cooled back to the initial intake temperature, the absolute intermediate pressure will be twice the absolute vacuum pressure (Ratio × initial pressure).

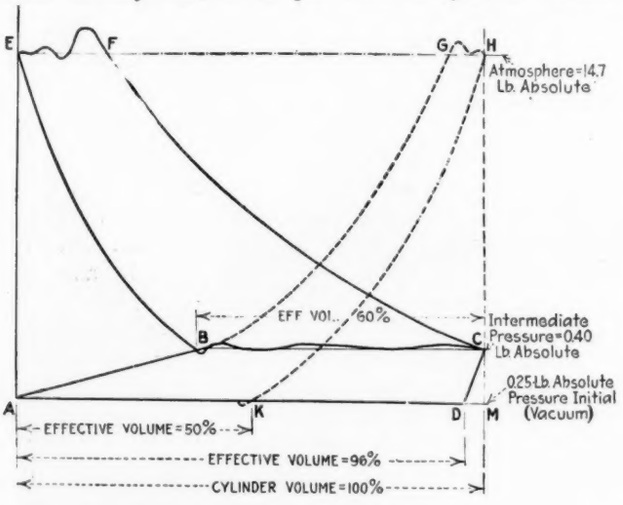
The effect of this intermediate pressure is to divide up the total number of compressions between the two cylinders, so that the low-pressure cylinder will be pumping through a much smaller range. Thus, assume a vacuum pressure of 1.5 lb. absolute, with a cylinder ratio of 2, giving an intermediate pressure of about 2¼ × 1.5 = 3.38 lb. absolute. Then the number of compressions in the low-pressure cylinder will be $\frac{3.38}{1.5} = 2.25$; whereas, with only single-stage pumping the compressions would have been $\frac{14.7}{1.5} = 9.8$. From the foregoing regarding the effect of clearance it follows that much less air will be trapped in the clearance space with only 2¼ compressions than with 9.8. Hence, the volumetric efficiency of the compound machine will be much higher than that of the single-stage.

If, instead of having a cylinder ratio of 2 to 1, we reduce it to 1.5 to 1, the intermediate pressure will be that much lower, the low-pressure compressions will be reduced, the clearance effect will be less and the machine will deliver more air. This process may be continued until finally the two cylinders become the same size, or the cylinder ratio becomes unity. Here it would seem the effect would become lost, because there would appear to be no intermediate pressure. This is where the clearance volume has a marked effect. It will be noted that if pumping from a given vacuum, say 1.5 lb. absolute, the total number of compressions will be $\frac{14.7}{1.5} = 9.8$, we accomplish 2¼ compressions in the low-pressure cylinder, the high-pressure cylinder must furnish the rest, or $\frac{9.8}{2.25} = 4.36$. Again, with the same vacuum, if we accomplish 1.5 of the compressions in the low-pressure cylinder we must have $\frac{9.8}{1.5} = 6.54$ compressions in the high-pressure cylinder. As the number of compressions in the low-pressure cylinder decreases, that in the high must increase to make up for it. The effect of decreasing the compressions in the low-pressure cylinder, we have seen, will increase its volumetric efficiency due to reduced clearance loss, so that the accompanying effect of increasing the number of compressions in the high-pressure cylinder will decrease its own volumetric efficiency due to its own clearance effect. The result of this is that the lower the cylinder ratio the more air the low-pressure cylinder will pump and the less air (cubic feet) the high-pressure cylinder will pump. This at once causes the low-pressure cylinder to build up an intermediate pressure higher than would result from the piston-displacement volume ratio only, so that even when the piston-displacement volumes of the two cylinders are identical there is an actual intermediate pressure and the machine is a true compound pump of greater output than a single-stage pump of the same size.

In the accompanying illustration will be found a set of diagrams which should help to make the conditions clear. First, consider a single-stage pump. Let the initial pressure of the vacuum be 0.25 lb. per sq.in. absolute, and discharging at atmosphere, of course. The indicator diagram would look something like the figure

ABGHK. The amount of air handled per stroke would be represented by length *AK*, if *AM* represents the full stroke of the piston. The diagram shows the intake air (and the delivery) to be 50 per cent. of the piston displacement, the curve line *HK* (dotted) shows the reëxpansion of the air trapped in the clearance space.

Instead of a single cylinder, let the machine be provided with two (compound) cylinders in series, each of which has the same displacement, namely, length *AM*. After operation for a few strokes the respective volumes and pressures will have adjusted themselves to the conditions shown by the two indicator diagrams *ABCD* and *CFEB*, the former being the first-stage, or low-pressure, diagram and the latter the second-stage, or high-pressure. With this set of conditions it will be seen that the creation of an intermediate pressure *BC* of 0.40 lb. absolute produced a reëxpansion curve *CD*, in the low-pressure diagram, indicating an air intake of length *AD*, or 96 per cent. of *AM* the whole cylinder volume, instead of only *AK*, or 50 per cent. of cylinder volume



Cylinder Volume Ratio=1
Cylinder Effective Ratio=$\frac{96}{60}$=1.6=Low-pressure Ratio of Compression
Approximate Intermediate Pressure=1.6×0.25=0.40 Lb. Absolute
High-pressure Ratio of Compression=$\frac{14.7}{0.4}$=36.7
Total Ratio of Compression=$\frac{14.7}{0.25}$=58.8

DIAGRAMS CONSTRUCTED FOR ONE- AND TWO-STAGE PUMPS

shown before. The intermediate pressure is a direct result of the lesser volumetric efficiency of the high-pressure cylinder, which itself results from the greater number of compressions in that cylinder, reëxpanding from the clearance volume.

If there is no intercooling of the air discharged from the first cylinder before it enters the second cylinder, the length of low-pressure discharge line *BC* must represent the volume taken into the high-pressure cylinder, shown to be 60 per cent. of the piston displacement of that cylinder. The line *EB* represents the curve of greater reëxpansion from the clearance of the high-pressure cylinder, due to the greater number of compressions or greater range of compression in that cylinder.

Of course these relative volumes and pressures in any given machine would depend upon the construction, clearance, degree of cooling, etc., of that particular machine. These values have been chosen to show in a rather exaggerated manner just how the actual compounding is brought about with equal cylinder sizes in series and to show the resulting increase in volumetric efficiency thus obtained. The question as to whether the results are worth the extra expense of the double construction is a matter to be decided by the purchaser. Some of the modern high-speed vacuum pumps of single-stage construction are giving such good results relative to their initial cost that the respective merits of different makes should be carefully considered before purchasing any particular style.

Soldering Commutators and Rotors

By Gordon Fox

The armature conductors of practically all direct-current machines are connected to the commutators by inserting the leads into the riser slots and soldering with hard solder. In like manner, the rotor bars of many squirrel-cage induction motors are connected to the end rings by mechanical insertion followed by soldering. It frequently becomes necessary to solder or resolder these connections. Repairs to the windings of a direct-current machine will ordinarily require the removal and resoldering of some of the leads. Also, overloads or other faults frequently cause overheating, followed by solder throwing, both with direct- and alternating-current motors. Since these soldered joints are depended upon for good electrical contact it is necessary that the soldering should be done thoroughly. Hard solder is used because of its higher melting point, hence lesser tendency to melt out through overheating. It is not an easy matter thoroughly to sweat in the connections with a soldering iron, although this can be done by dint of skill and patience.

Several methods have been developed to render this operation more reliable and, at the same time, to have it performed more easily and cheaply. One simple method utilizes a trough-like vessel (a casting will answer) about 4 in. wide, 3 in. deep and 1 ft. long. This vessel is used as a container for solder, which is melted by means of a large torch or gas burner. The armature or rotor to be soldered

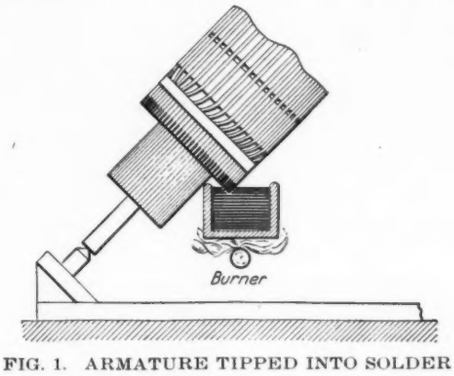


FIG. 1. ARMATURE TIPPED INTO SOLDER

is mounted between centers at an angle, as illustrated in Fig. 1, and the vessel containing hot solder is brought to such a position that the corner of the armature is slightly immersed. The angle of the shaft may be varied to control the relative distance the solder reaches upon the outside and upon the face of the risers. The riser joints having been previously cleaned and treated with soldering flux, the immersion causes the hot solder to sweat through them thoroughly. As the work progresses the armature is slowly rotated so that new sectors enter the bath.

After one complete revolution of the armature the job is finished. In the case of a squirrel-cage rotor of an induction motor, one end is sweated in, then the rotor is inverted and the process repeated on the other end. In soldering direct-current armatures it is often advisable to shield the windings from the heat radiated from the solder

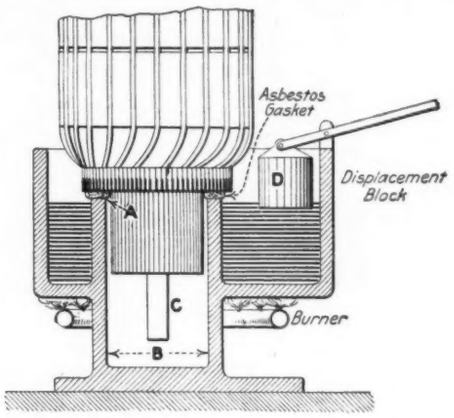


FIG. 2. SOLDER DISPLACED BY PLUNGER

by wrapping a piece of sheet asbestos around the circumference of the armature just above the risers.

This method is used for rotors and for arms having open risers. If the solder is sufficiently hot it will run off the riser tips and simply sweat through to the interior and plate the exteriors. Lumps do not form between the risers unless they are extremely close together or unless the solder is not hot enough. Maple wedges are sometimes driven between the risers before soldering, not so much to prevent lumps forming between the risers as to give the risers sufficient stiffness so that they can be turned after soldering, the riser fork being made long and extending out from the arm. On repair work where the risers are of the correct length to begin with this is not done.

Another method which is somewhat more rapid, finds use particularly on the smaller direct-current armatures having solid risers. This device is somewhat more elaborate than the preceding one. The solder is melted in a special annular vessel as shown in section in Fig. 2. The armature is mounted vertically, with the commutator entering chamber *C*, the solid risers resting upon an asbestos gasket. The level of the solder is normally below the point *A*. When the displacement block *D* is forced down into the metal the level rises and the hot solder reaches the risers, sweating in the joints all around the circumference simultaneously. It requires some little time for the hot metal to overcome the chill and thoroughly to sweat in the connections. The solder should be very hot. In drawing up a device for this work the diameter *B* should be made wide enough for the largest commutator for which its use will be required. The opening at *A* can then be reduced and adapted for smaller commutators by means of cover-plates having different bores.

This method is used for soldering armatures having solid risers, the riser being a part of the segment itself. It is possible by controlling the amount of immersion of the displacement block to regulate the height of the solder at the riser to a nicety so that the solder does not get behind the head of the commutator. It is not necessary to bring the solder up even with the head of the commutator, since it will sweat itself upward to some extent.

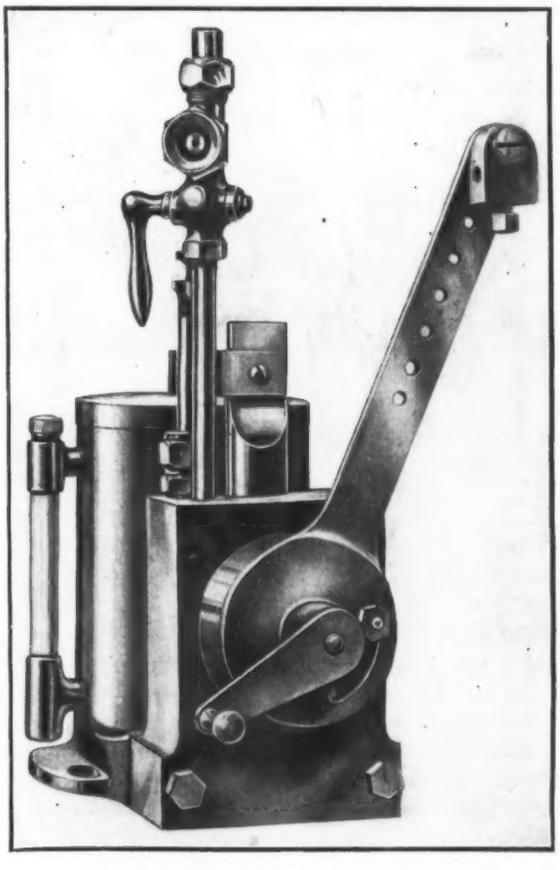
New Clutch Drive Lubricator

After successful tests covering more than a year on an engine running at 800 and another at 275 r.p.m., Greene, Tweed & Co. announce the new Rochester automatic lubricator. As the illustration shows, the familiar pawl and ratchet have been replaced by a clutch drive. This drive is perhaps the chief improvement. It does away with the noise of the pawl, and a noiseless lubricator and positive lubrication are secured. Notwithstanding that it is a clutch drive, there is a regulating device, which, by changing the position of the adjustment pin in the actuating arm, causes more or less lost motion.

Another new feature is the stuffing box. It is stronger and larger and permits the use of more packing which is forced against the plunger rod by a spring pressing against the packing from below.

If the gage glass breaks, a valve in the lower fixture automatically shuts off the oil and the lubricator keeps on running just as though nothing had happened.

The principal working parts are incased and protected from dirt and grit, yet all parts are easily get-at-able.



SHOWING INCLOSED CLUTCH DRIVE

All the mechanism is compactly centered in a steel pump block, which can be almost instantly detached from the bowl or reservoir. This gives easy access to all working parts for cleaning or repairing, without disturbing the reservoir attached to the engine.

Close regulation of feed is a feature, and three ways of adjustment are offered—by changing the position of the adjustment pin in the actuating arm, by regulating the adjustment screw in the plunger, and by changing the position of the rod connection on the actuating arm. Once adjusted, any amount of oil, from the tiniest drop

to an almost continuous stream, is fed steadily, regardless of pressure, vacuum or temperature. Each independent feed is equipped with an improved vacuum and check valve, so that it is unaffected by any vacuum in the cylinder that might otherwise siphon the oil from the oil line.

Each feed is also equipped with a multiplus sight feed—that is, a combination of the three-way cock and a patent sight-feed device. The three-way cock shows the size and number of drops discharged by the pump, and also the movement of the oil as it passes to the point of delivery.

The sight feed is constructed so that the oil passes through a circular chamber inclosed by a heavy glass disk. The outlet in the center of this chamber contains a hollow plug or plunger and the oil to pass through this outlet must compress the plunger, which moves in and out, flashing or blinking, according to the pulsations of the pump, showing plainly the movement of the oil being delivered as it passes the sight glass to its destination.

Experiences of Refrigerating Troubleman

By C. E. Anderson

SYNOPSIS—Experience of the kind you like to read about but not to be responsible for. One engineer tries sand, water and compressed air for scouring a double pipe condenser. He succeeds, but as a result the compressor requires reboring in midseason. In another plant, a disordered gage is responsible for 60-lb. suction pressure, while in still another plant the unscrewing of a nipple in the liquid receiver creates a near mystery.

At overhauling time last winter one engineer decided that he would like to clean the double pipe condensers (both the ammonia and the water sides) without removing all the return bends—a tedious and time-killing job. The condensers had been thoroughly coated with a lime and iron deposit from the well water in use and were badly in need of cleaning. The ammonia side was dirty and coated with a liberal quantity of oil.

The solution of the difficulty presented itself when it occurred to the engineer to scour out the pipes with compressed air, using a mixture of sand and water under 20-lb. pressure. The device which he used to do the work is shown in Fig. 1.

The writer had just finished reboring the ammonia cylinders in this plant, and it was the middle of the ice season, too. The engineer deserves some credit, however; he cleaned the condenser until the inside shone like a new coin. But also considerable sand slipped down into the evaporating coils and up the suction line to the compressor, where all the damage was done. This gave the writer the job of reboring the cylinders. This man did not foresee that he would scour the ammonia compressor cylinders when he cleaned the condenser.

An Untruthful Gage Makes Trouble

The writer was informed by the chief engineer of a hotel that the ammonia machine would not refrigerate. The first step was to apply the usual remedy—pumping back. The suction pressure was dropped to 0 lb., but the writer could not get any frost on the return pipes. Usually such pumping back "livens up" the system, makes the dormant liquid lying in refrigerating pipes evaporate, and improves the working of the plant in general, especially when there is a shortage of liquid. The regulating valves had ammonia rushing through them, and from experience it was evident that if such was the case no refrigeration could be done in the evaporating coils, as the liquid could not evaporate; but if the pressure was below 45 lb. (the temperature of the liquid and gas is then about 32 deg.), at least some frost should appear at the inlet and outlet, especially at the inlet. The liquid, having been formed at about 86 deg. F. in the condenser, must spend a certain amount of itself to cool the remainder to the temperature prevailing in the evaporating or refrigerating coils before it can do useful work, and when the suction pressure is even 27 lb., the temperature is 14 deg. F.; so the moisture condensed on the outside of the inlet pipe, behind the regulating valve, should have been frozen; but it was not. This showed clearly that the suction pressure was higher than the gage indicated. Examination of the liquid receiver showed the level of the liquid dropped regularly at every stroke of the compressor, indicating plainly that the compressor was pumping liquid instead of gas. The temperature of the brine was 32 deg. F., and therefore it is evident that the liquid entered

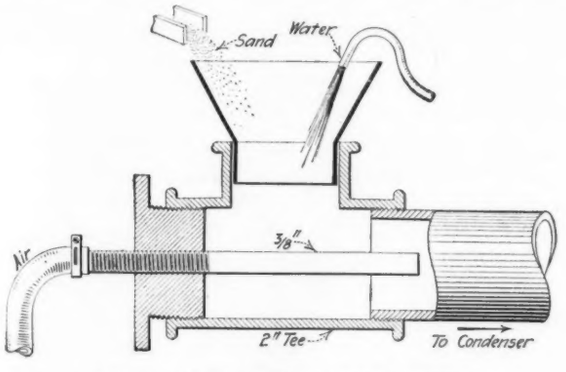


FIG. 1. SAND AND WATER MIXER

could not evaporate, as gas, liquid, and brine were of the same temperature and could therefore not exchange heat.

It was noticed that the glass front of the suction gage was broken, and the writer supposed that a man sweeping had brushed the glass out and moved the hand at the same time. The gage cock was closed and a joint between the gage and cock broken. The hand came down far below 30 in. of vacuum. On resetting the hand to 0, corresponding to the atmospheric pressure (under which the gage then was, being freely exposed to it), it was found upon connecting the gage that the suction pressure was 60 lb.

The work of setting the system in order again may be imagined. Every pipe, tank and the compressor froze over in a short time, and to get the machine in proper condition quickly, hot water had to be poured over the frozen parts. After a few hours' work the machine was in good order, except that the condensing pressure was too high. The engineer had put in a large quantity of liquid just before the writer arrived, thinking that the fault was shortage of ammonia. Considerable liquid was removed

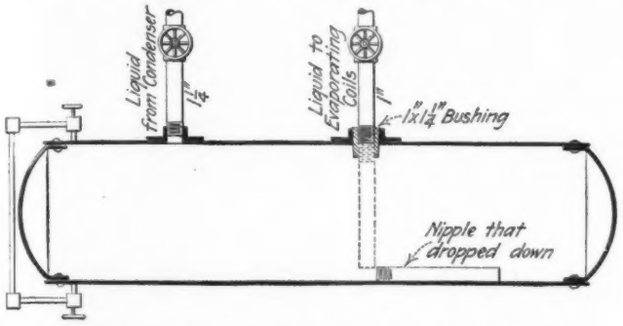


FIG. 2. SHOWING WHY COILS GOT NO AMMONIA

before the condenser pressure dropped to normal. In fact the condenser was partly filled with liquid; therefore the available condensing surface was reduced and the condensing pressure increased.

Good Reason Why Coils Got No Ammonia

On entering the engine room the writer met the chief, who informed him that the ammonia compressor had quit working, would not pump gas, and that the brine was steadily rising in temperature, although there was a tankful of half-frozen ice, a combination that would turn a man's hair gray, to use the chief's expression.

The compressor was running hot, but the suction and discharge valves all sounded right and were in apparently good order, so it was concluded that the trouble must be elsewhere. On examining the liquid receiver the gage glass indicated it was three-quarters full, which was plenty. On examining the regulating valves for the evaporating coils in the ice tank, they all seemed free and open; and on listening to the valve closely, nothing but gas was heard passing through, which showed that the trouble must be between the regulating valves and the liquid receiver. This was a rather puzzling situation, as gas was passing through the liquid lines and therefore they could not be clogged up in any way.

The writer opened the regulating valves on the ice tank wide and went back into the engine room to see what effect, if any, it had on the compressor. He was leaning against the liquid receiver watching the suction and discharge gages and had his hand on top of the receiver at the liquid line outlet. Suddenly the space around the outlet under the writer's hands commenced to get cooler and cooler. The cause was suspected. The liquid could not get out of the receiver but was being evaporated and superheated, and was being pumped through the expansion coils in the ice tank.

All the ammonia possible was removed from the liquid receiver into some empty ammonia drums and the rest was evaporated and pumped through the ice-tank coils and stored in the condenser. After the receiver was empty and well pumped out, the liquid line to the expansion coils was disconnected, and here was found the trouble. The nipple that runs to within 1 in. of the bottom of the receiver to the liquid outlet line had unscrewed, probably from vibration in the engine room, and was lying in the bottom of the receiver as shown in Fig. 2. With considerable patience and a stiff wire it was fished out.

Before the nipple was connected to the liquid line a hole was drilled in the reducing bushing and the nipple riveted to make sure it would not unscrew again. After connecting the pipe, charging into the system the ammonia which had been removed, letting the entrained ammonia in the condenser down into the receiver, adjusting the regulating valves on the ice tank and bringing the compressor up to speed, everything was back to its normal working condition, and another ammonia mystery was solved.

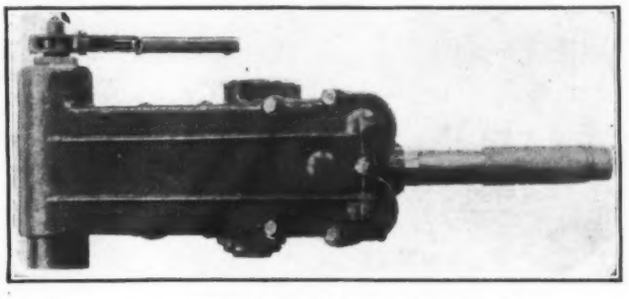
New "Little David" Drill

The tool shown in the accompanying illustration is a recent addition to the "Little David" line of pneumatic tools manufactured by the Ingersoll-Rand Co., 11 Broadway, New York City.

The tool is particularly adapted for working in cramped or confined positions, where the regular type of four-piston, reciprocating pneumatic drill cannot be used, the distance from the end of the casing to the center of the spindle being only $1\frac{5}{16}$ in.

The motor is of three-cylinder design and operates in a bath of oil. The valve is of the rotary type and is gear driven from the pinion of a three-way crankshaft. This crankshaft is operated by three ratcheted levers that directly connect the pistons to the drill spindle.

There is practically no strain on the crankshaft, as the power is transmitted direct from the pistons through the



EXTERIOR OF "LITTLE DAVID" DRILL

levers to the triple ratchet spindle, and one of the ratchets is engaged on the spindle at all times. The casing is divided in such a way that the loosening of a few cap screws allows easy access to all moving parts. The drill can be dismantled and reassembled in 30 min. It is fitted with a No. 4 Morse-taper socket and is rated for drilling up to 3 in., reaming and tapping to 2 in. and operates at a speed of 150 r.p.m.

The Density or Specific Gravity of Oil or any other fluid may be easily found, using a true scale and an accurate measure, by a comparison of the weights of equal volumes at the same temperature. For example, if a cubic foot of water weighs 62.5 lb. and a cubic foot of oil 50 lb., the specific gravity of the latter is

$$50 \div 62.5 = 0.8$$

Or a measure of water may weigh 10 lb. and the same measure of oil only 8 lb.; then

$$8 \div 10 = 0.8$$

is the specific gravity, as before.

Acceptance Test of High-Speed Poppet-Valve Engine

SYNOPSIS—The rapid strides being made in the design of high-efficiency engines in small and moderate sizes are illustrated by the results of an acceptance test on one of the five Nordberg poppet-valve engines recently built for the Laclede Gas Light Co. Rankine efficiencies are obtained on these which are equal to and better than the efficiencies of 30,000-kw. steam turbines.

A modern four-valve poppet-valve engine, even in small sizes, will give extremely high efficiencies, as shown by the test given herewith, wherein the Rankine efficiency at the best load is almost 80 per cent., the engine operating on slightly moist steam at 130-lb. gage. With superheated steam the Rankine efficiencies go well above 80 per cent.

The 15x18-in. poppet-valve engine tested was for driving a positive displacement blower and is fitted with hand speed control instead of the standard shaft inertia governor. A section of a typical engine of this design is shown in Fig. 1, and the distinctive features of construction are as follows: The cylinder proper is a plain cylindrical casting free to expand and contract like a piece of pipe, and all the valves and steam ports are contained in the heads.

The steam enters near the bottom and sweeps over the surface of the head on its way to the inlet valves located at the top. The valve seats are formed in removable cages set in the heads and the valves are of the balanced type, operated positively by a single cam oscillated from an eccentric on the lay shaft. Springs are not used to close the valves. In the engine tested the speed governor was omitted and speed control obtained by the handwheel shown in the foreground of Fig. 2. This wheel operates

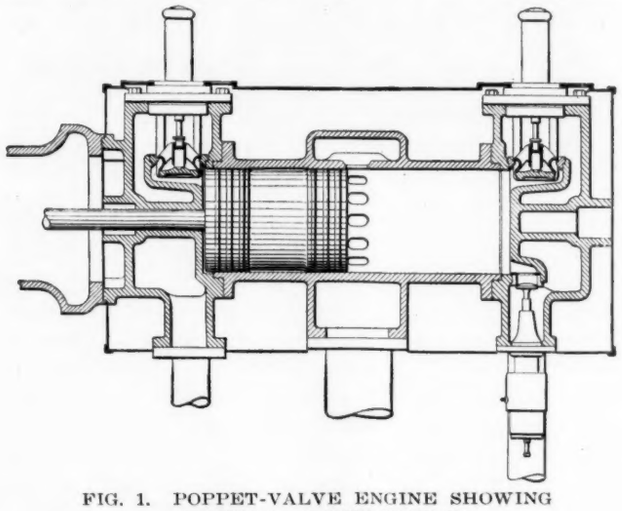


FIG. 1. POPPET-VALVE ENGINE SHOWING CYLINDER CONSTRUCTION

to vary the relative position of the eccentrics on the lay shaft. An emergency governor driven by a belt is also provided and may be seen at the top of Fig. 2.

The photographs show the arrangement for testing this engine at the works of the Nordberg Manufacturing Co., Milwaukee, Wis., the readings being witnessed by a representative of the Laclede Co.

Power was measured by the prony brake shown in the foreground of Fig. 3 with standard scales, as shown in Fig. 4. Special precaution was taken in measuring condensate. A large surface condenser was used and to this was added a small auxiliary condenser to obtain added cooling surface. The small condenser may be seen above and to the right of the main condenser in Fig. 4. This excess of cooling surface assured a reduction in water

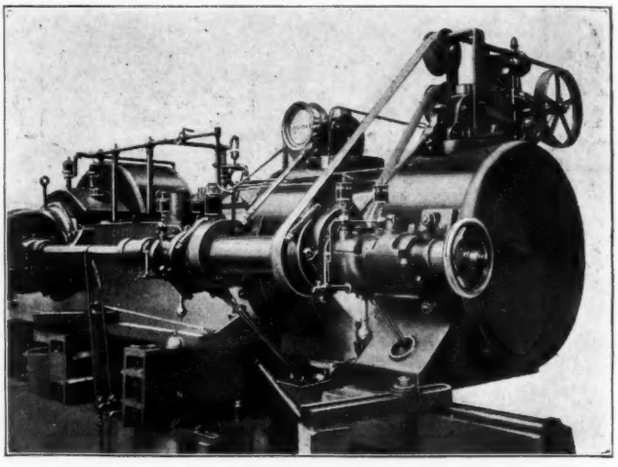


FIG. 2. SHOWING THE EMERGENCY GOVERNOR

temperature from 212 deg. down to the room temperature, so that there was no loss of vapor from the weighing tanks. The latter are shown at the extreme left of Fig. 4, the piping being provided with quick-acting valves to divert the condensate from one tank to another. Pressures and temperatures were taken by standard calibrated instruments and speed was read by a tachometer, and also a total revolution recorder. Indicator diagrams were taken at regular intervals of 10 minutes by Ashcroft indicators with calibrated 100-lb. springs. Typical diagrams are shown in Fig. 5 at 31.7, 60.7, 82 and 92.75 lb. m.e.p. Attention is drawn to the fact that the steam line holds up horizontally and to the unusually well-defined cutoff obtained. These diagrams are remarkable for an engine running at 200 r.p.m. and show conclusively the excellence of the poppet valve and gear design.

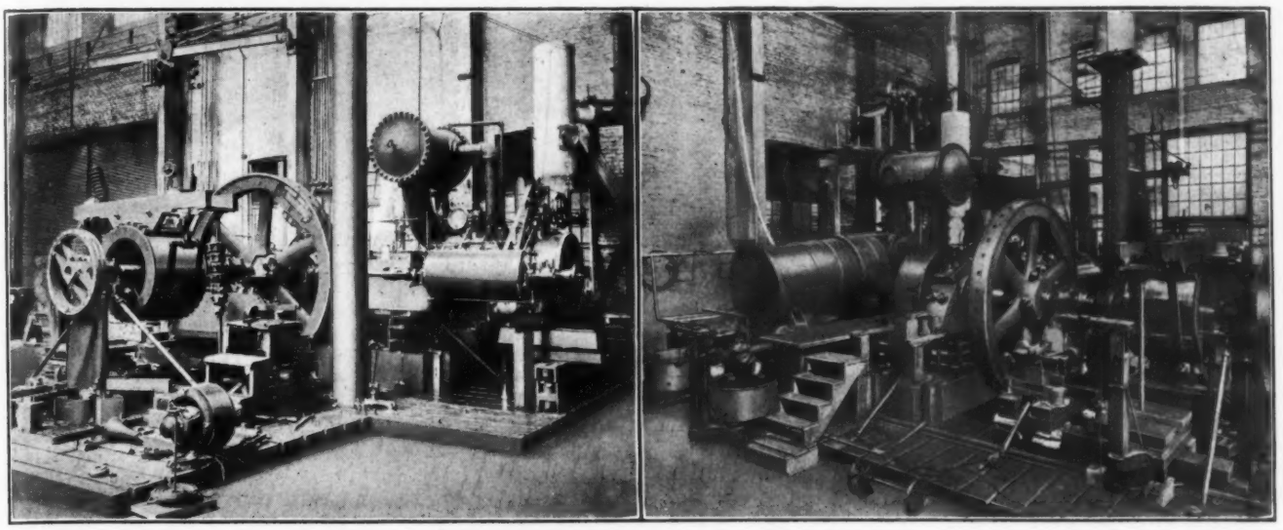
The following table shows the results of the acceptance test at approximately 200, 150, and 100 hp. loads and 200 revolutions in a 15x18-in. Nordberg full poppet-valve engine running noncondensing.

RESULTS OF STEAM CONSUMPTION TEST

Date	March 27, 1915		
Duration of test	1 hour	1 hour	1 hour
Average speed, r.p.m.	199.71	200.3	200.4
Steam pressure, lb. gage	130.0	130.03	130.8
Average back pressure, lb. gage	0.24	0.19	0.19
Quality of steam	0.986	0.99	0.987
Average brake load, b.hp.	185.8	150.0	111.2
Average m.e.p., lb. sq.in.	62.58	50.83	39.0
Average i.hp.	197.0	160.1	123.0
Mechanical efficiency	0.94	0.937	0.908
Water measured in condenser, lb. per hour	4125.5	3211.0	2287.0
Water condensed in cylinder head, lb. per hour	79.0	49.0	61.0
Total water condensed, lb. per hour	4204.5	3260.0	2348.0
Dry steam admitted to engine, lb. per hour	4150.0	3225.0	2320.0
Steam consumption:			
lb. per b.hp. per hour	22.32	21.48	20.75
lb. per i.hp. per hour	21.05	20.15	18.85

At the best load the steam consumption of 18.85 lb. per i.hp. corresponds to an efficiency, referred to the Rankine cycle, of 79.9 per cent., a remarkably high result for 130 lb. steam containing about 1 per cent. moisture. The total water measured was corrected for this moisture and the steam rate is given on the customary basis of dry steam. Moisture in steam greatly aggravates cylinder condensation, and when superheats of 100 to 150 deg. are used the Rankine efficiencies rise above 80 per cent.

On the basis of brake horsepower the Rankine efficiency is 72.6 per cent., the difference being accounted for by the mechanical efficiency of the engine, which is 91 per cent. In an engine of so small a size, 150 hp., and operating with wet steam at low pressure an efficiency of 72 per cent. on a brake-horsepower basis is unusually high. These efficiencies are based on steam rates that include the steam condensed in the jacketed heads of the engine, which was about 3 per cent. of the total condensate.



FIGS. 3 AND 4. TWO VIEWS OF TEST EQUIPMENT WITH PRONY BRAKE AND SCALE IN FOREGROUND

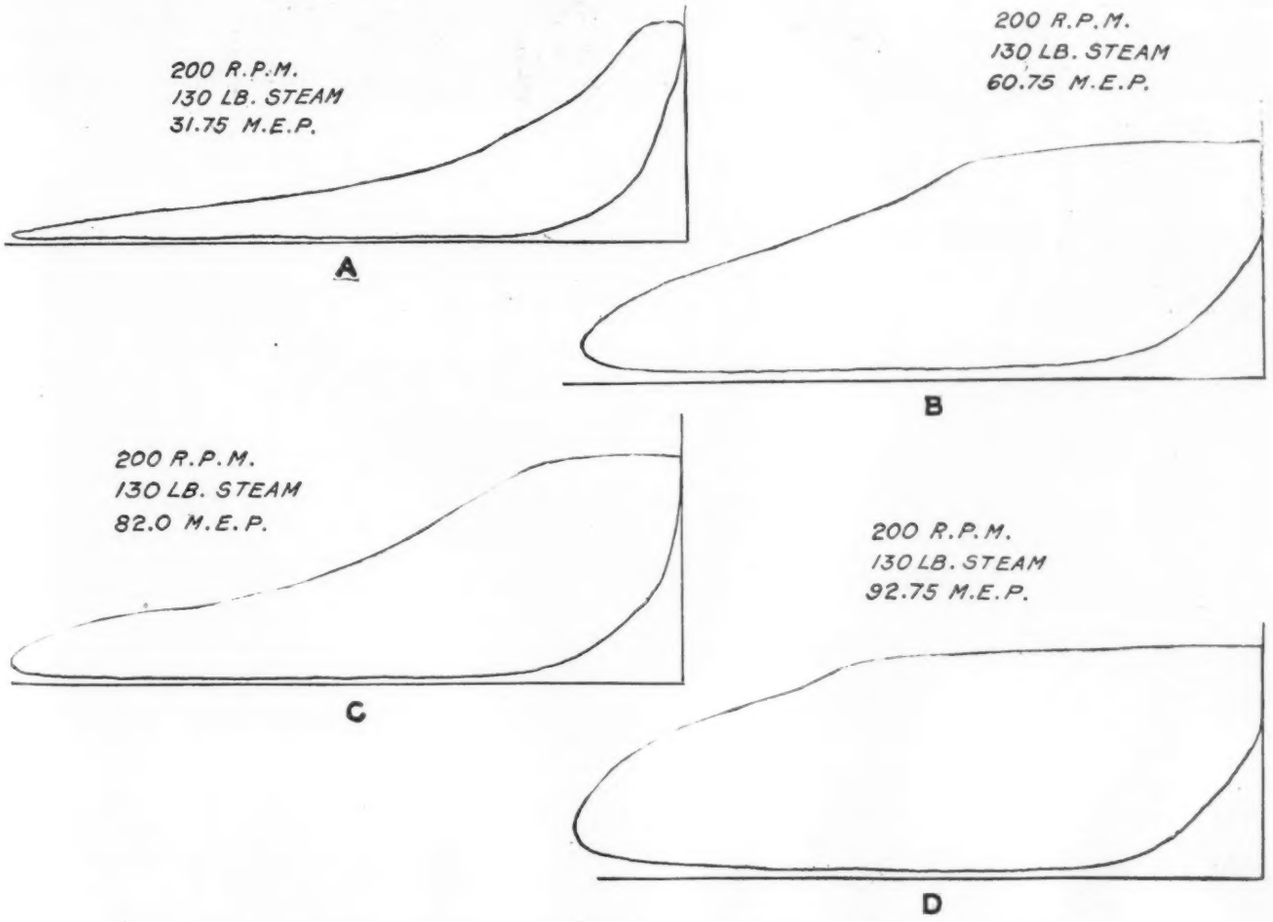


FIG. 5. TYPICAL INDICATOR DIAGRAM FROM AN ENGINE RUNNING AT 200 R.P.M.

Columbus Refrigerating Plants

SYNOPSIS—A brewery, a cold-storage plant and an ice-making concern operate three of the largest refrigerating plants in Columbus, Ohio. In the ice-making plant the recent installation of an engine and shaft drive instead of steam-driven units increased the quantity of ice obtained per ton of coal from 7½ to 16 tons. The light and power apparatus in the three plants are also considered.

The largest plant in the city is in the Hoster branch of the Hoster-Columbus Associated Brewery Co., which has an annual capacity of from 350,000 to 400,000 bbl. of beer. This plant is equipped with three 220-ton vertical compressors, Fig. 1, driven by tandem-compound Corliss engines. These units supply a 75-ton can-ice plant and about 600 tons of refrigeration. For lighting and power there are one 200-kw. and two 50-kw. direct-current generators, all driven by cross-compound engines. The large unit is run during the day and one of the small machines at night, although at times a 50-kw. and a 200-kw. unit are operated in parallel. The prime movers exhaust to four surface condensers, usually operated in parallel. Cooling water is obtained from wells on the premises and the supply is conserved by two forced-draft cooling towers, one for the steam and one for the ammonia condensers. The boiler room has four 450-hp. double-deck water-tube boilers, with superheaters and inclined grate stokers. The operating pressure is about 125 lb. and the superheat 100 deg. There are also four 300-hp. water-tube boilers without superheaters. Both sets of boilers are connected to a common steam drum 4 ft. in diameter and 12 ft. long, from which all the steam for the various units is taken.

Ohio or West Virginia coal is crushed and elevated to a 350-ton bunker by a bucket elevator and screw conveyor. It is then dropped into another screw conveyor and passes through chutes to the stoker hoppers.

Since much of the condensate is used in the ice plant, the feed water is mostly cooling water taken from the ammonia-condenser hotwell. From the hotwell it is pumped through a closed heater into live-steam purifiers and then flows by gravity to the boilers.

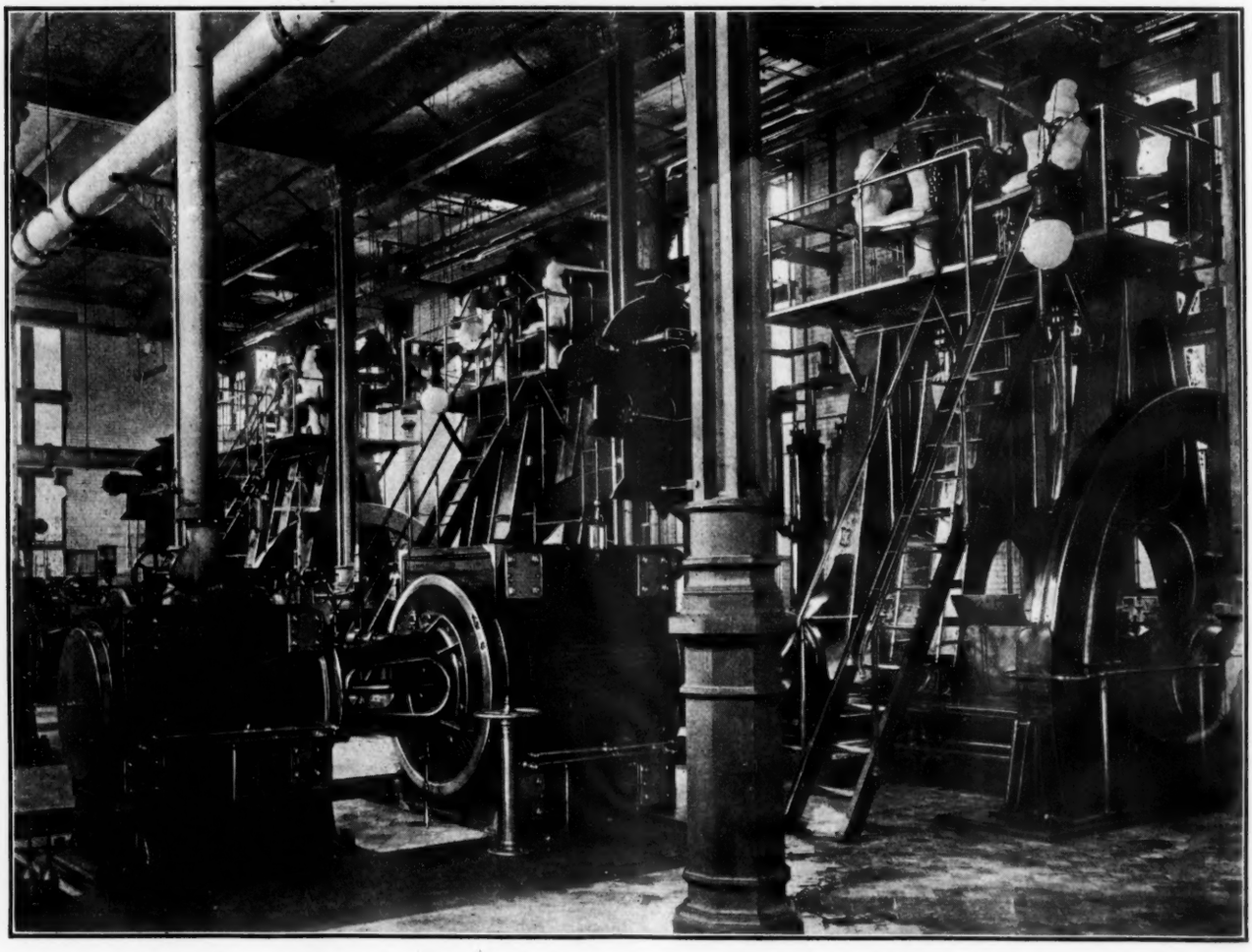
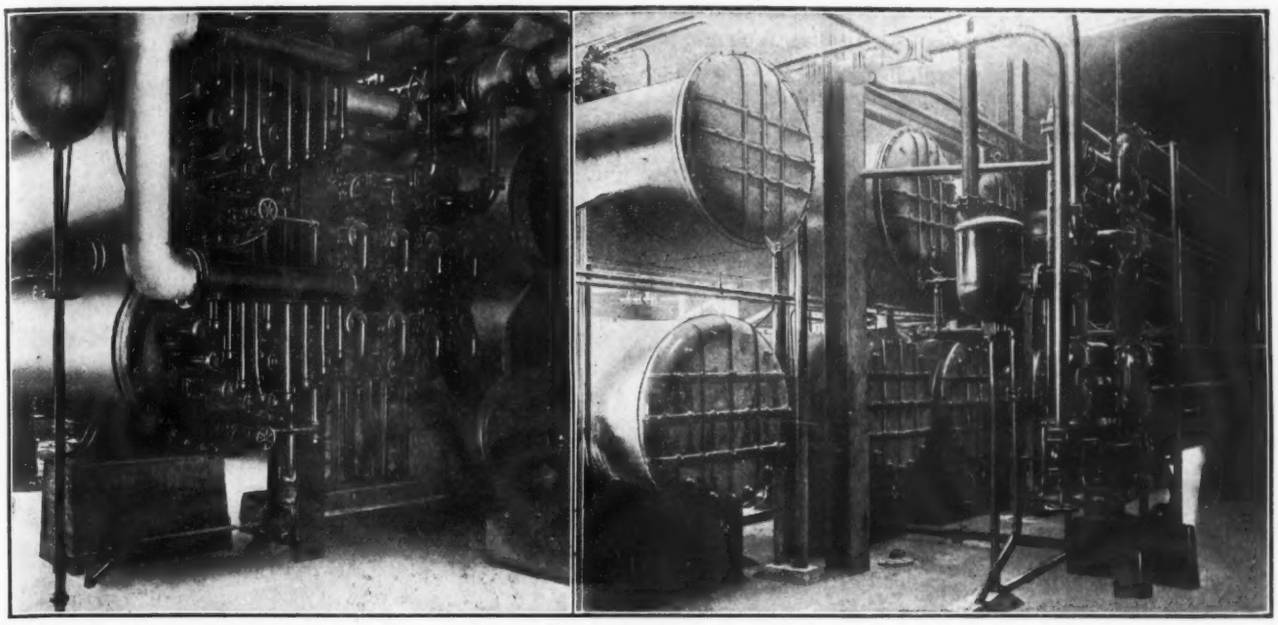


FIG. 1. THREE 220-TON AMMONIA COMPRESSORS AT THE HOSTER BREWERY

National Company's Absorption Plant

The National Ice and Storage Co. has two units with a capacity of 400 tons of refrigeration. There are 160 tons of ice-making machinery, 80 tons of refrigeration, 1,000,000 cu.ft. of general storage and 500,000 cu.ft. of cold storage. Each unit consists of the usual ammonia



FIGS. 2 AND 3. APPARATUS AT PLANT OF NATIONAL ICE AND STORAGE CO.

Fig. 2—Generators of 400-ton absorption plant

Fig. 3—Condensers, absorbers and dehydrators

pump, generator, exchanger, dehydrator, condenser, absorber, weak liquor cooler and flat cooler, as shown in Figs. 2 and 3. The weak liquor cooler and the flat cooler are of double-pipe construction, the other apparatus being of the shell type. The general storage is cooled by a brine system, while the cold storage is equipped with direct-expansion coils. The ice is pulled with electric cranes, and an automatic device drops two 300-lb. cakes at a time from the third story to the basement.

On the roof is the forced-draft cooling tower, 35 ft. high Six screens break up the water and 42-in. fans on each of the four sides deliver 16,000 cu.ft. of air per minute into the tower. The reboiling of condenser steam is done on the roof. The water then flows back to the flat cooler, then to the fore coolers and finally to the ice cans.

Light and power are supplied by a 125-kw. three-phase 60-cycle generator driven by a simple engine. The exhaust from this and other steam auxiliaries is utilized

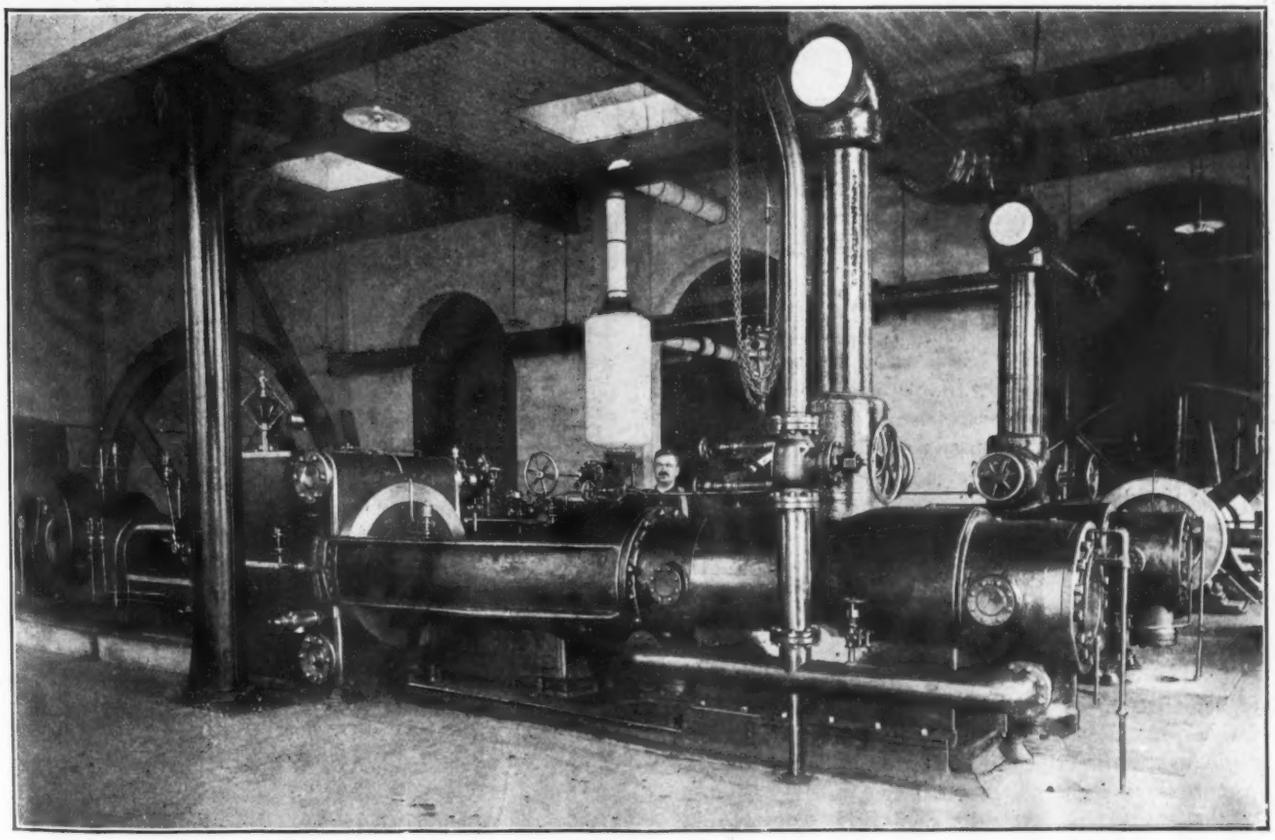


FIG. 4. ENGINE AND COMPRESSOR, GROCERS AND BUTCHERS ICE COMPANY

in the absorption system, so that the back pressure ranges from 15 to 30 lb. At times the exhaust is supplemented with live steam.

The three 200-hp. return-tubular boilers are equipped with underfeed stokers, automatic regulators and with counters to record the weight of coal. The coal is delivered from the railway track, passed through crushers and elevated by a bucket conveyor into a 200-ton steel bunker, from which it is chuted to the stoker hoppers. The working boiler pressure is 125 lb.

Raw- and Distilled-Water Ice Making

The ice-making plant of the Grocers & Butchers Ice Co. has a daily capacity of 200 tons and was originally equipped with two 16x30-in. double-acting compressors driven by 20x42-in. simple Corliss engines. Then there were steam-driven pumps, air compressors, an electric lighting unit, brine agitators, brine pump and induced-draft apparatus, using from 50 to 150 lb. of steam per horsepower-hour. It became evident that if this apparatus were driven more efficiently, a decided gain in the economy of the station would result. Consequently, a cross-compound engine, Fig. 4, with 21&40x36-in. cylinders and a guarantee of 14 lb. of steam per indicated horsepower, was installed. Between the cylinders is a 16-ft., 40,000-lb. flywheel, which drives a line shaft on the second floor by an American rope system. This line shaft extends the full length of the building and drives the auxiliaries previously mentioned. The same engine drives by tail rods an 18x36-in. compressor that supplies air for raising water and for an 18x36-in. ammonia compressor. There are three wells 250 ft. deep on the premises, and the air lift will raise 750 gal. per min.

In addition to the engine 40-ton raw-water and 40-ton distilled-water tanks were installed, increasing the daily output from 120 to 200 tons. The change resulted in obtaining 16 instead of 7½ tons of ice per ton of coal, an increase credited to the new equipment.

Some Special Features in the Plant

The oil is separated from the exhaust steam drainage, decreasing the daily evaporation by about 10 tons of water or increasing the distilled-water supply about 5 per cent. The oil is also used again, after being washed and passed through a grease extractor.

The surface condenser for the new Corliss engine is set vertically and has 2-in. iron tubes. The condenser is open at the top, and the tubes can be cleaned while it is in operation. The water in the plant was bad, containing as high as 170 grains of solids per gallon, so that no small-tube condensers could be used; consequently 2-in. tubes were used. Good circulation and heat transmission are insured by air agitation. About 40 to 50 cu.ft. of free air per minute is admitted at the bottom of the condenser, and in passing up through the tube it agitates the water so that there is but little opportunity for stratification.

A flat cooler, two atmospheric steam condensers and the boiler feed-water heater are also built with 2-in. tubes set vertically. The doors between the ice tank and transfer room are automatically opened and closed by the cakes of ice. John R. Smith, superintendent of the plant, has originated a miniature trouble detector that will save an entire tank of ice. There are other features of interest, but the best way is to visit the plant and see the earmarks of genius first hand.

De La Vergne Oil Reclaimer

Oil used for lubricating the bearings and the pistons of oil or other types of internal-combustion engines soon becomes foul with carbon and other impurities, making it unfit for continual use without the danger of clogging up the oil-cup feed and the ruining of the engine bearings.

If a sample of this oil is put away for settling, it will even after many months show no satisfactory separation. The carbon is contained in such microscopically small particles that the difference in specific gravity is not sufficient to produce any practically considerable motion downward. But if the same oil is mixed with water and heated, and a suitable reagent is introduced, a surprisingly rapid settling of the carbon sets in, caused by the formation of comparatively big carbon particles out of the formerly

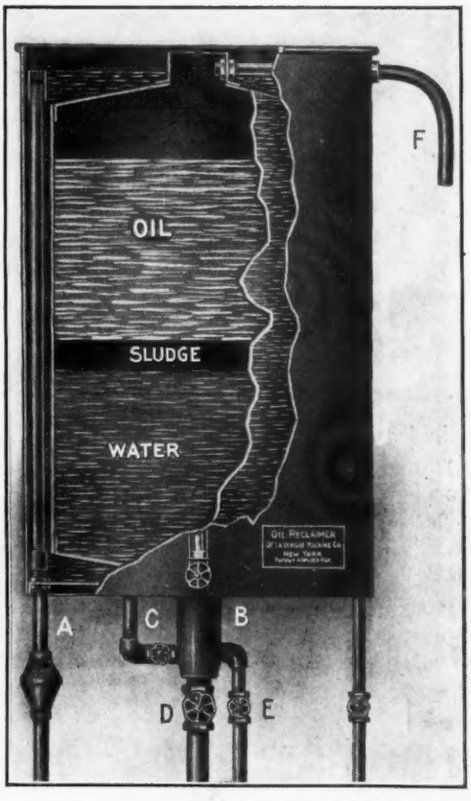


FIG. 1. SEMI-SECTIONAL VIEW OF THE RECLAIMER

small particles; and after a short time all carbon will have settled to a layer of spongy sludge. The oil on top of that layer is clean; the water below contains the reagent, which is insoluble in oil, and of which the clean oil contains not the slightest trace.

On these principles a new oil reclaimer has been designed and thoroughly tested by the De La Vergne Machine Co.'s power specialty division, foot of East 138th St., New York City.

Fig. 1 is a semisectional view of the reclaimer. It consists of an outer shell in which is an inner receptacle containing the oil to be reclaimed. The space between the inner and outer tank is nearly filled with the hot circulating jacketing water from the engine, the exact height being fixed by the nipple on the end of the overflow pipe *A*. At the bottom of the reclaimer there is a special casting *B* to which the pipes *C*, *D* and *E* are connected. At the top of the inner tank, connecting with the open dome, is

the oil pipe *F*, through which the clear oil is discharged to the storage tank, from which it is fed to the engine bearings.

Fig. 2 shows how the reclaimer and storage tanks may be supported by wall brackets. Fig. 3 shows a typical installation. The reclaimers are made in 40- and 75-gal. sizes. The operation of reclaiming the oil is as follows:

In the smaller size, for instance, 40 gal. of dirty oil from the drip tank of the engine is put into the reclaimer, to which are added 40 gal. of hot water and about 8 lb. of "Oilite," the coagulant. The mixture is then agitated by compressed air for about 20 min., and the contents of the reclaimer then allowed to settle for from 12 to 24 hr. The hot jacketing water from the engine circulates through the reclaimer between the two shells, while the oil is left to settle. After settling the water is found at the bottom of the inner tank, next the layer of sludge, and on the top the clear oil, ready to be drawn off to the storage tank for using again.

The oil is removed from the reclaimer by opening the valve *C*, which connects the inner with the outer tank. This brings the level in the inside tank higher than the water level in the outside tank, because oil is lighter than water, and the oil will overflow through the pipe *F*. The nipple on top of the overflow pipe *A* is so adjusted that the nipple in the inside tank has just come down below the opening of the pipe *F* when all clean oil is drawn off. Then the valve *C* is closed and the valve *D* opened,

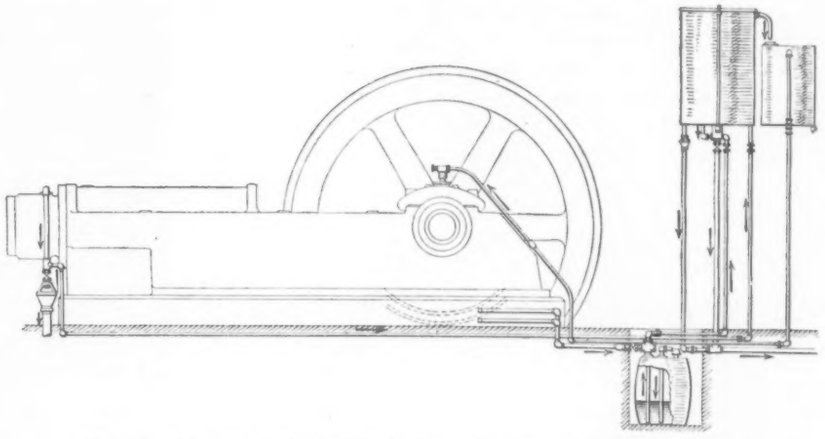


FIG. 3. CONNECTIONS BETWEEN ENGINE AND RECLAIMER

which allows the water and sludge to flow to the sewer. The reclaimer is then ready for more dirty oil.

The operation of the apparatus is simple and almost automatic. It requires less than 24 hr. for treating as much oil as its capacity calls for, and the total cost per gallon of oil recovered will approximate one cent.

A feature that will appeal to engineers aside from the reclaiming of oil that is generally thrown away is that there is no necessity for cleaning the reclaimer, other than discharging the sludge and water through the clean-out valve. There are no parts to renew, and no oil is lost by absorption in filtering material.

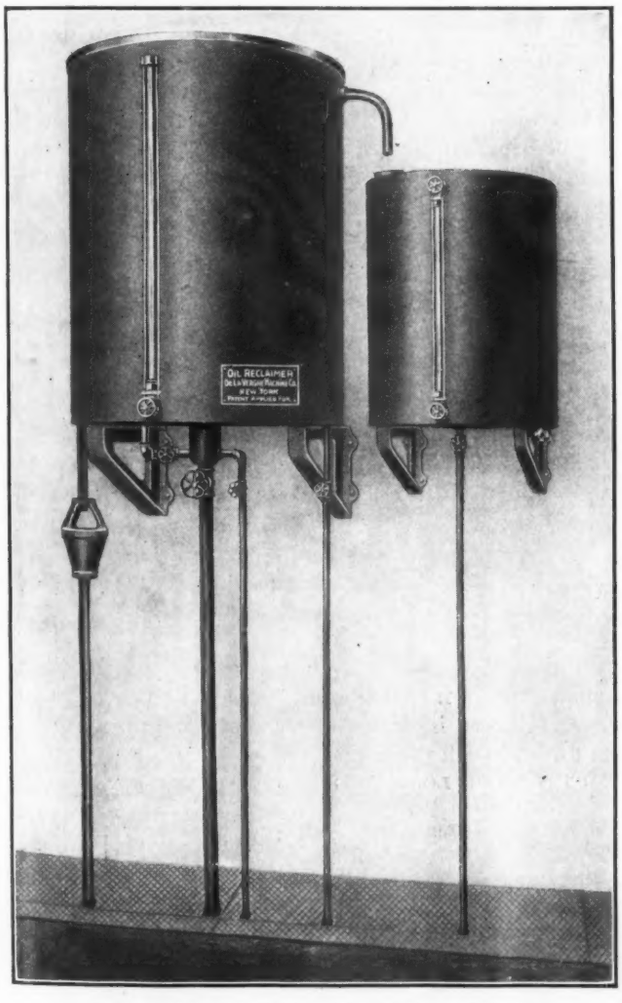


FIG. 2. RECLAIMER AND STORAGE TANK

To Mend a Hammer Handle

Most attempts at mending cracked or broken tool handles are bungling and unsightly affairs, and the splices are usually weak and soon give way.

The method described herewith forms a neat metal sleeve shrunk around the weak section of the handle which is not only strong but also neat and compact.

The first operation is to wind closely the weak section with soft copper wire. Common bell wire from which the insulation has been stripped will do very well. The coils should lay close together, and should extend for about half an inch either way beyond the weak section of the handle. A rig similar to the spring-winding fixture shown in *Power* of May 18, 1915, p. 692, will help in winding the wire on the handle (as well as wrapping hose connections and the like). When the coils are in place twist the free ends of the wire together, in order to keep them from slacking off or unwinding; then cover the coils with soldering flux and solder them together. Flow the solder over the joints until it forms a solid metal sleeve. When it has cooled, smooth it with an old file. Do not use a new file, as the solder will fill it up and spoil it.

Although one sees this type of repair applied most often by machinists to hammer handles, it can be used on almost any type of tool handle met with in the shop or home. If not too badly shattered, a handle so banded will last a long time and be slightly flexible and will relieve the severe jar.

High Vacuums with Surface Condenser

Whereas it is difficult to set down what the limits may be to the steam pressures and superheats which it will pay to carry in future power-plant practice, there are certain definite limits to the lowest temperatures at which the steam may be exhausted.

With a natural supply of cooling water the lowest temperatures at which heat may be rejected vary from 32 deg. in the winter to 70 and 80 deg. in the summer. The vacuum corresponding to 32 deg. is 29.82 and that corresponding to 70 deg. 29.26. Condenser practice has now advanced to a point where vacuums at the turbine exhaust of 29.4 to 29.7 at loads from full down to one-quarter load are obtained in the winter with 32-deg. water and of 28½ in summer with 70-deg. water.

To obtain high vacuums the essential requirements are the careful operation and exclusion of air leakage from all piping and apparatus under vacuum, starting at the steam turbine and terminating with the air pump. Then there is

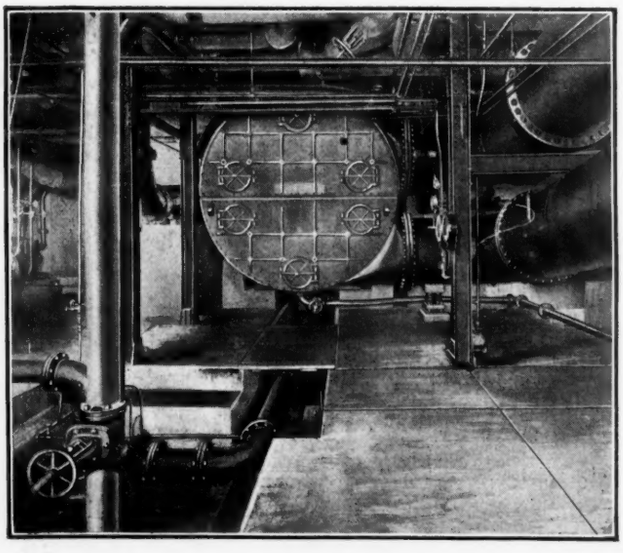


FIG. 1. CONDENSER CONTAINING 27,000 SQ.FT. OF COOLING SURFACE

the efficient air removal which is accomplished by modern forms of air pump, of both the turbo-air type and the dry-vacuum type. The former will maintain 99 per cent. of the vacuum corresponding to the temperature of the water when fully loaded in connection with a condenser, and this means a vacuum within a few tenths of that corresponding to the temperature of the circulating water. Dry-vacuum pumps of improved type maintain within one-tenth of an inch of the barometer on dead ends, and the vacuum falls off only a few tenths when handling normal condenser air leakage (see following test).

Good steam distribution is necessary and the increase in the size of the exhaust nozzle of high-vacuum turbines has assisted considerably in securing distribution of steam over the entire condenser. Where the exhaust nozzle is smaller than the projected area of the condenser, flared connecting pieces are built, and these have a slight venturi effect, besides serving properly to distribute the steam.

Spacing of the tubes is a matter of fundamental importance. It pays to invest money in tube spacing as well as in tube surface, and it is actually possible to decrease the vacuum obtainable with a condenser by adding tube surface into a shell of small diameter.

Many high-vacuum condensers with rotary hurling-water air pumps have been described in *Power*. The

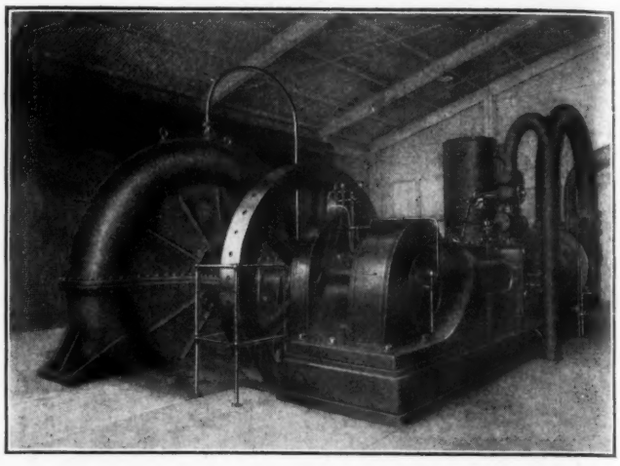


FIG. 2. STEAM DRIVEN AIR AND CIRCULATING PUMP UNIT

construction and efficiency of a high-vacuum outfit with a dry-vacuum pump will be of interest in comparison.

Recently a 20,000-kw. installation was made by the Wheeler Condenser & Engineering Co., Carteret, N. J., at the Cleveland Electric Illuminating Co., comprising a 27,000-sq.ft. surface condenser and a reciprocating dry-vacuum pump and slow-speed circulating pump driven by a four-valve non-releasing gear engine.

Photographs of the condenser and auxiliaries are reproduced in Figs. 1 and 2. The condenser contains 5724 tubes of 1-in. diameter, arranged in two passes. The spacing of the tubes was given particular attention, with the

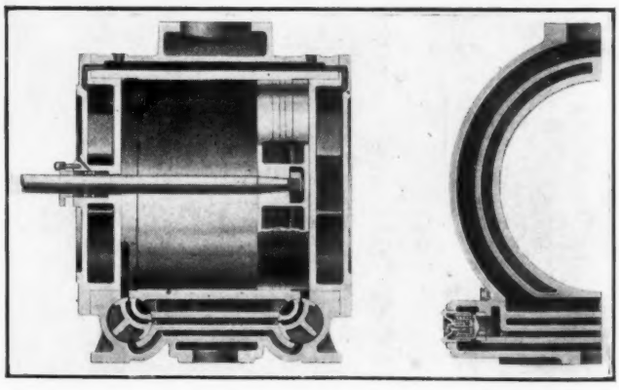


FIG. 3. SHOWING THE VALVE IN THE AIR PUMP

result that the pressure drop was exceedingly low. A vacuum of 29.7 in. maintained at one-quarter load and 29.4 at full load indicates a very small margin for pressure drop through the condenser.

TABLE OF LOAD AND VACUUM MAINTAINED

Load	Temp. Water In	Temp. Water Out	R.p.m. Pump Rated Speed, 75 R.p.m.	Vacuum Referred to 30-In. Barometer
17,500	35.6	50	53	29.40
10,000	35.6	45.5	53	29.65
5,000	35.6	41.5	54	29.70
15,000	35.6	48	56	29.47
16,000	35.6	48.7	56	29.45

One of the features of this installation is the air- and circulating-pump unit. There are two schools of auxiliary design—the high-speed turbine-driven air and circulating

pump and the reciprocating type pump and slow-speed circulating pump. The latter makes a complete self-contained unit of low steam consumption and of slow speed, a feature which appeals to many operating men. The circulating pump is of the split-case, double-suction, inclosed-impeller type, and has an efficiency of approximately 80 per cent. The steam cylinder is of the four-valve non-releasing Corliss type.

The air cylinder is of the new and recently invented design, in which the flash or equalizing port feature of smaller dry-vacuum pumps with a single valve has been successfully applied to the two-valve pumps. In large pumps a valve is required at each end to keep down the clearance volume. The flash ports of the two valves must register with the cylinder ports and with the flash passage extending from end to end of the cylinder. This is secured by the proper setting of the valves, so that for a short instant at dead center communication is established to reduce the air pressure in the clearance space down to the suction pressure on the other side of the piston. In Fig. 3 the valves are shown in position for equalizing the pressure. On test with blanked air suction the pump maintained a vacuum of 29.8 referred to a 30-in. barometer.

System of the Columbus Railway and Light Co.

SYNOPSIS—The Columbus Ry. & Light Co. has over 18,000 kw. in turbines and engines scattered among six stations. An Edison three-wire system lights the business district; 575-volt direct current is provided for street-railway service and 4150-volt three-phase feeders supply the outskirts. A load-dispatching system serves to operate the apparatus at the highest efficiency and to minimize service interruptions.

The privately owned public-service company of Columbus, Ohio, generates current in six stations, ranging in size from 240 to 14,350 kw. For street-railway service direct current at 575 volts is supplied. An Edison three-wire system lights the business district, and a network of 4150-volt 60-cycle three-phase feeders covers most of the rest of the city. The Spring St. station, Fig. 1, the most uptodate of the six plants, has a capacity of 14,350 kw. There are four alternating-current turbo-generators, with a total rating of 11,000 kw., and four compound engine-driven direct-current units for railway service. The engines were installed between 1899 and 1903. The first turbine, a 500-kw. vertical machine installed in 1904, is one of the pioneers in the field. A 1500-kw. vertical turbine was installed in 1906, a 4000-kw. horizontal-reaction turbine in 1911 and a 5000-kw. impulse-reaction machine in 1913. The equipment thus shows the development in prime movers during the last 15 yr. Motor-generators connect the direct-current and alternating-current busses, so that either set of machines may supply either service. The main units are operated condensing with cooling water from the Scioto River.

In the boiler room fourteen 350-hp. and four 500-hp. water-tube boilers operate at 175-lb. pressure and 100 deg. of superheat. The 350-hp. boilers have three sets of economizers, but on the four 500-hp. boilers, Fig. 2, installed in 1910, the economizers were omitted. Chain grates serve 14 of the boilers. Two of the smaller size have underfeed stokers and two are hand-fired. Natural draft is used on the last four and induced draft on the others.

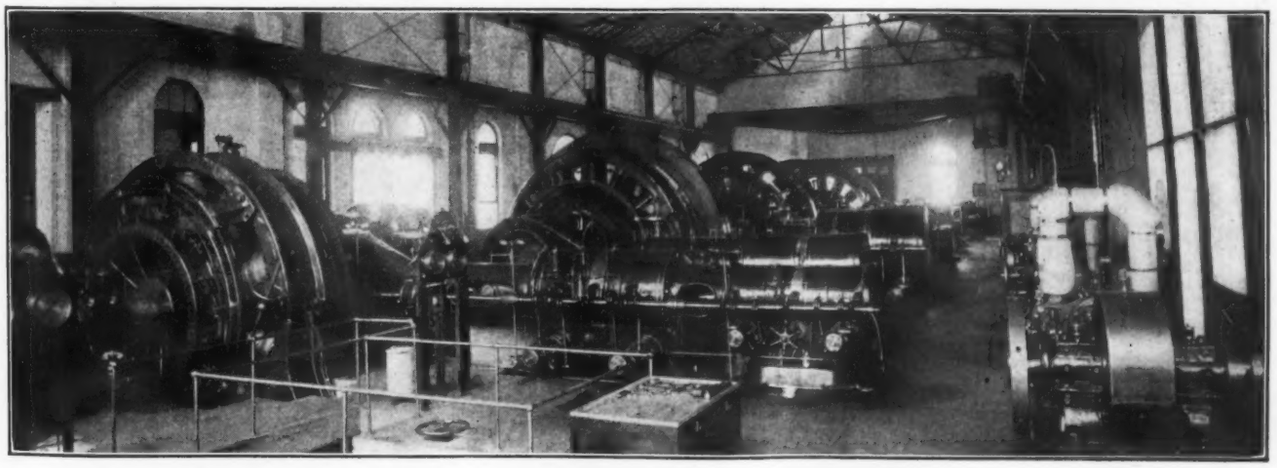


FIG. 1. RAILWAY GENERATING UNITS AT THE SPRING STREET STATION

Although during the 1913 flood there was nearly 6 ft. of water on the engine-room floor at Spring St., only one of the machines was permanently injured. The rest were dried by standard house-heating furnaces burning natural gas. Each generator was boxed in with lumber and asbestos paper and in ten days' time was thoroughly dried by four furnaces. Within 48 hr. after the water was below the floor level the current was going out of the station from a 1500-kw. vertical unit, which the water did not reach.

Gay St. station, the next largest plant, has 2400 kw. in its four vertical cross-compound direct-current generating units. This station supplies the three-wire Edison system in the downtown district. The generating equipment is supplemented by over 3000 kw. in motor-generator sets. Whenever possible the station load is carried by the more economical units at Spring St. In one of the 1000-kw. motor-generator sets, the motor drives two 500-kw. generators on the same shaft. It may be operated in parallel at from 250 to 300 volts to supply the Edison three-wire, or in series at from 500 to 600 volts for the street-railway service. The railway and lighting peaks do not come together, so that the outfit has proved exceptionally useful. There are also two storage batteries in the station.

The Mound and 17th St. station has 1100 kw. in cross-compound engine units and a 1000-kw. turbo-generator, all generating 4150-volt alternating current. The station is run only during the colder months, when it furnishes exhaust steam for a hot-water district-heating system operated by the company. The hot-water heater has 5000 sq.ft. of surface and is built for 50-lb. pressure. It is used as a condenser, the vacuum running up to 20 in., depending on the temperature of the water desired in the system. The temperature is regulated according to a schedule influenced by wind velocity.

The boiler equipment consists of six 350-hp. units, three with chain grates, while three have semi-Dutch ovens and are hand-fired. The other three stations are small and are seldom used. They are held mainly for emergencies, such as heavy peaks or serious breakdowns in the larger stations.

All power stations and substations are tied together by both high- and low-tension transmission lines. As much load as possible is carried on the Spring St. station. The generating equipment is so widely scattered that the responsibility for its proper handling is placed on a load dispatcher rather than on the engineers in the various stations. Consequently at the Gay St. station an office, Fig. 3, has been equipped with maps, telephones, a recording barograph and electrical instruments, so that the dispatcher can properly operate the system. A separate telephone system connects all stations and substations and is so arranged that he may confer with the switchboard operators in all the stations. On the board at the left of

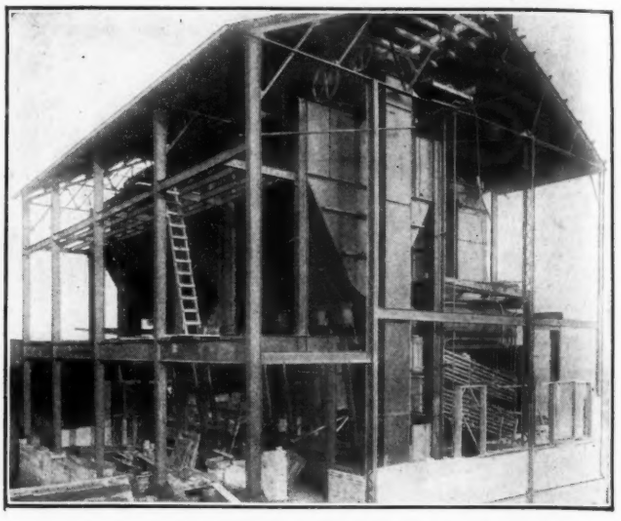


FIG. 2. FOUR 500-HP. BOILERS INSTALLED AT SPRING STREET IN 1910

Fig. 3 is represented the power system. Each generating station and substation is indicated by a large circle. Within the large circles there are smaller circles for each generator, motor-generator, rotary and battery in that station. Near the small circles are lamps with different colored lenses to indicate the kind of current delivered. Tie lines between the stations are indicated by a distinctive color and line switches by spring buttons, the positions of which show whether the line is in or out of service. Push-buttons on the dispatcher's desk light the lamp correspond-

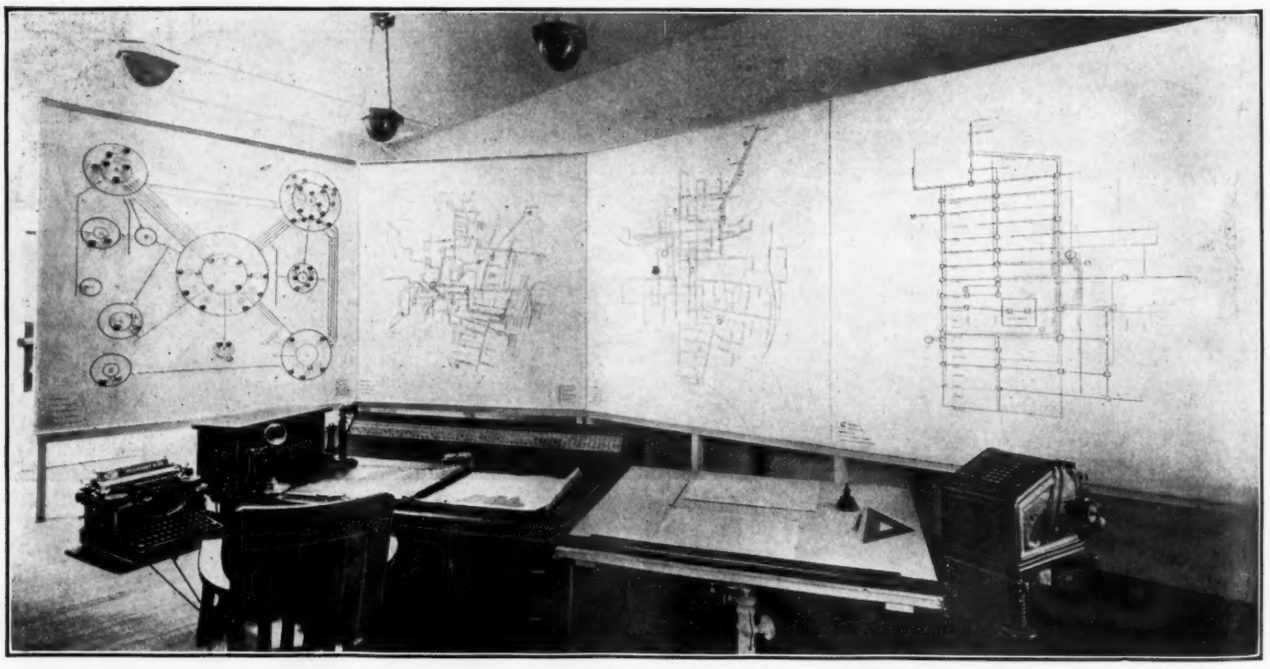


FIG. 3. OFFICE OF LOAD DISPATCHER AT GAY STREET STATION

ing to the machines placed in operation, so that a glance at the board will give the number of machines in service.

The second board from the left is a map of the city, showing the alternating-current system and all tie and primary lines to and between stations. The third board is also a city map, and shows railway feeders in one color and the double- and single-trolley lines in another. The underground system in the center of the city is outlined on the fourth board. The positions of junction boxes, manholes, feeders and distributing circuits are shown. All necessary information is thus placed at the disposal of the dispatcher. The system has given excellent satisfaction.

The Panama-Pacific Exposition--V

By F. R. Low

SYNOPSIS—Description of the heavy-oil engine using a hot bulb and self-ignition with a low degree of compression, commonly known as the semi-Diesel engine. Three makes are exhibited.

The Semi-Diesel Engines

Of the semi-Diesel or hot-bulb type three are represented—the Mietz & Weiss, of New York; the Bessemer, of Grove City, Penn., and the Venn-Severin, of Chicago.

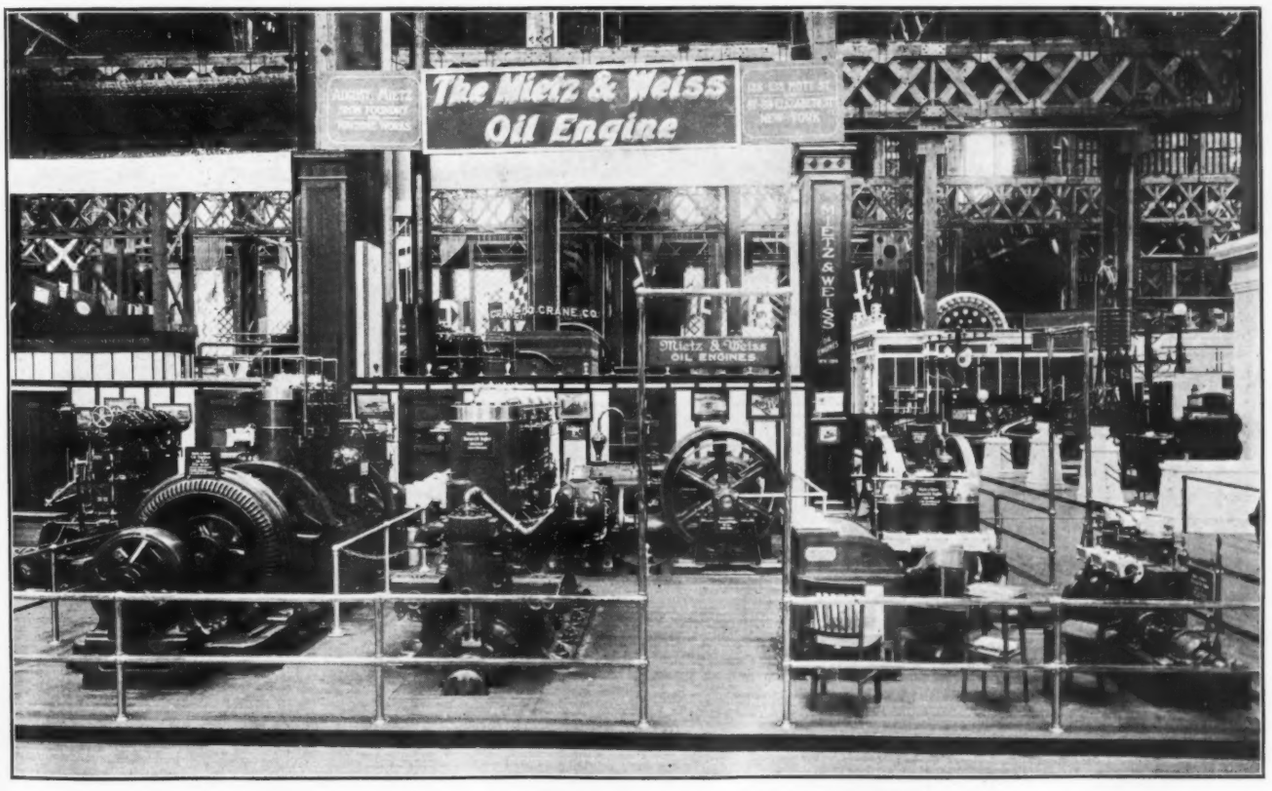


FIG. 24. EXHIBIT OF SEMI-DIESEL ENGINES BY MIETZ & WEISS

All are two-cycle; the Bessemer is horizontal, the Venn-Severin, vertical, and the Mietz & Weiss, both vertical and horizontal.

The Mietz & Weiss exhibit is shown in Fig. 24 and the engine in section in Fig. 25. The bulb *A* is heated by the torch *B* before starting, and after the engine is in operation the torch is extinguished and the temperature of the bulb kept by the combustion of the fuel in regular working up to a temperature which will bring its contents above the ignition point of the fuel at a comparatively low compression, about 100 lb. The fuel is injected at *C* in quantities measured by the governor which controls the stroke of the feed pump. A single pump is used for all cylinders. The incoming air enters the closed crank case through the port *H* when that port is uncovered by the piston on its upper stroke, and is compressed after the piston closes the port on the downstroke to about 3 lb., at which pressure it enters the cylinder through the port *E*, being deflected upward by the lip *F* and expelling the burnt gases through the exhaust port *G*. Vapor from the waterjackets is drawn in with it through the pipe *K*, and the cock *J* allows enough jacket water to go in with it to prevent preignition. The Mietz & Weiss exhibit comprises a vertical marine with their new reversing gear having four 14x18½-in. cylinders, and developing 200 hp. at 240 revolutions; a three-cylinder vertical attached to a 50-kw. G. E. generator, a 60-hp. marine, a direct-connected air compressor, a 50-hp. single cylinder horizontal, and several smaller engines.

The Venn-Severin engine, a section of which is shown in Fig. 26, is also a crank-case compression machine. Air from the case enters the cylinder at *A*, exhausting at *B*. The hot bulb is inclined to the axis of the engine, and the nozzle discharges against the edge of its throat. Water from the jacket is injected with the fuel when a tendency to preignition is manifested, and the engine shown, which is a 60-hp., standing in the collective exhibit of a Western agent, has an attachment said to regulate automatically the water injected in accordance with the temperature, but information concerning it was unprocurable.

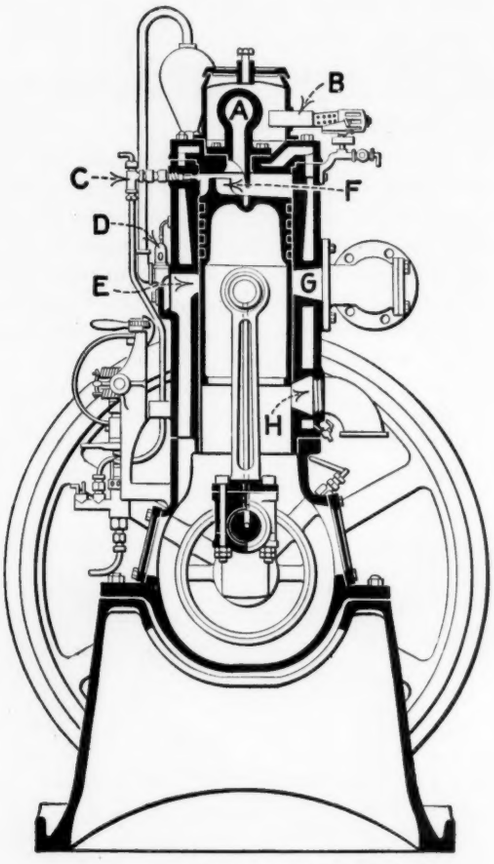


FIG. 25. THE MIETZ & WEISS ENGINE

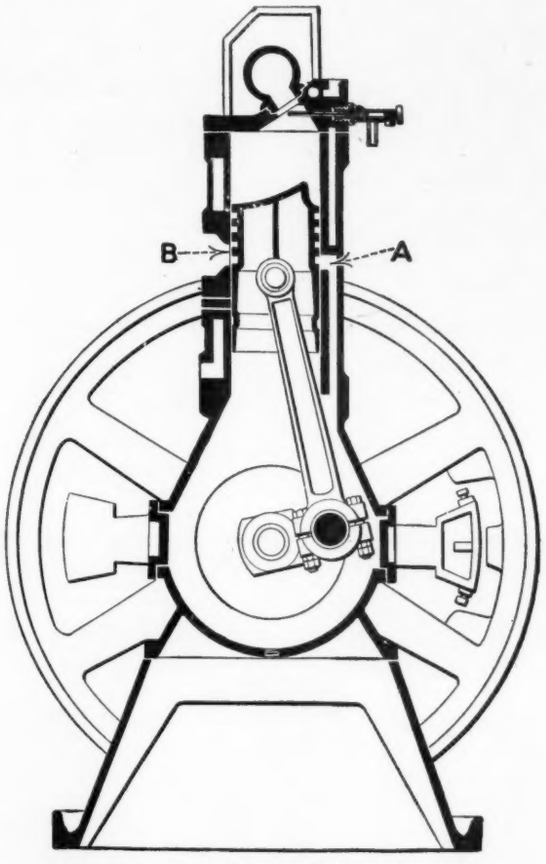


FIG. 26. THE VENN-SEVERIN ENGINE

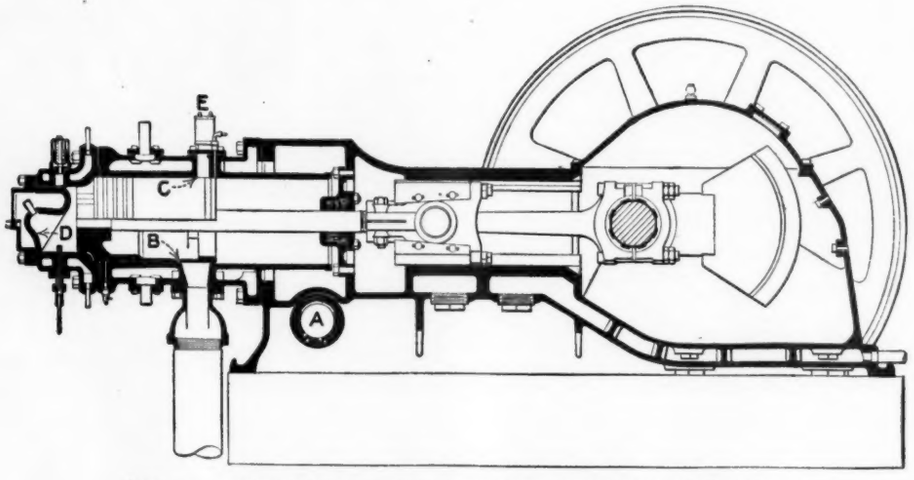


FIG. 27. SECTION OF THE BESSEMER SEMI-DIESEL ENGINE

The Bessemer engine is horizontal, and follows steam-engine practice, using a Tangye frame and a crosshead. Compression of the scavenging charge takes place not in the crank case, as in the two previous examples, but in the front end of the cylinder, admission being controlled by the semi-rotary valve *A* in Fig. 27. The piston first uncovers the edge *B* of the exhaust port, and when it reaches the edge *C* of the air-inlet port air flows in from the crank case under a pressure of about 5 lb., is deflected headway, sweeping out the products of combustion and filling the cylinder with fresh air to be compressed on the return stroke. On the hot bulb *D* is a hollow projection which is all that requires to be heated preparatory to putting the engine into operation. A compression pressure of about 180 lb. is used. Water is delivered to a glass cup *E*

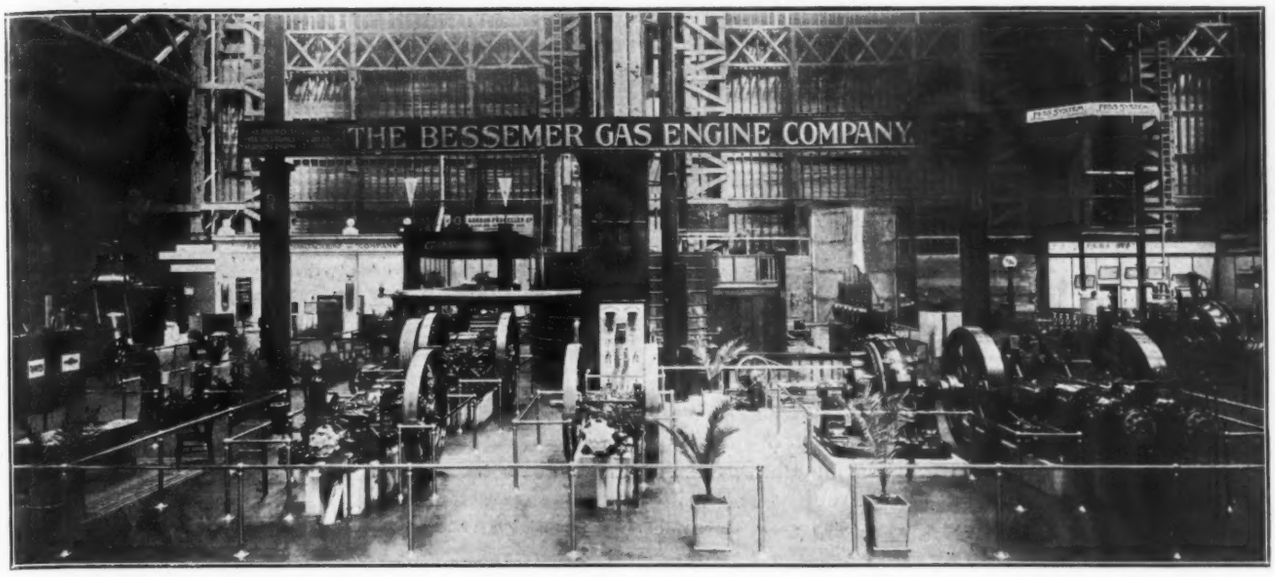


FIG. 28. EXHIBIT OF SEMI-DIESEL ENGINES BY THE BESSEMER GAS ENGINE CO.

by a pump which is under the control of the governor, so that the amount of water injected varies with the fuel used in the same time; but a hand adjustment enables the operator to vary the volume at any time, after which it will still remain proportional. This water flows down into a screened trough, and is picked up by air entering at *C*.

Organization at Delray

By Norman G. Reinicker

SYNOPSIS—A brief summary of the operating force and the respective duties of department heads. The advantage of council meetings at Delray, attended by the operating, maintenance, testing and electrical engineers, the yard superintendent and the chief and assistant chief engineers of the plant.

The chart, Fig. 1, gives the actual organization. The assistant engineer at Delray in charge of the operation and maintenance of the plants reports directly to the chief engineer of all power plants of the company. Under the direction of this assistant engineer there are seven engineers between whom are apportioned the details of work as shown on the chart. The maintenance engineer is responsible for the upkeep and repair of all buildings and apparatus, exclusive of electrical equipment. He keeps complete records of repairs made and the costs of doing the work; makes regular and systematic inspection of every piece of apparatus, doing the necessary work to keep that apparatus in the best condition; and maintains in the storeroom necessary stock and spare parts for regular or emergency repairs, as past experience of his best judgment dictates.

The foreman electrician has complete charge of the maintenance and care of all electrical equipment and the operation of the Delray substation. All switchboard operators report to him.

The testing engineer conducts routine tests on turbines, boilers, etc., and makes a complete bound report of his findings to the assistant engineer. He is also responsible for the collection and analysis of all coal and ash samples, the reports of which are submitted on printed sheets made for that purpose. All steam gages, draft gages, vacuum gages, CO_2 machines, etc., are regularly tested and kept in order by the routine testing department. This department also collects the necessary data and does the work of making up reports showing the thermal operation of the plant. It receives from the accounting department of the company the charges against the various operating accounts and from these makes a report on the total and unit costs of operation. From these charges detailed analyses of the various labor costs are also made.

The yard superintendent is responsible for the operation of the Delray terminal railroad, the equipment of which consists of 21 cars, 2 locomotives, and 5 locomotive cranes. He receives the coal cars from the railway company, weighs and unloads them at the base of the coal tower and then returns the empty cars. He also maintains the railroad and track equipment, bridges, sidewalks and grounds around the plant. The watchmen around the grounds report to him.

The plant runs on three eight-hour shifts. On each of these shifts there is an operating engineer who has complete authority over the whole plant and who carries all responsibility at the time. By the testing engineer he is furnished with the results of all tests that are made upon boilers, turbines, etc., and so is kept posted as to the condition and best running point of the machines. He makes decisions as found necessary during his particular shift or follows instructions of the assistant engineer, passing the word along to the oncoming operating engineer of any general scheme he may be following on any particular day. These departures from normal operation are due in most cases to conditions arising at the time. In the various parts of the plant

there are foremen, as shown on the chart, who report to the operating engineer and carry out his instructions.

The operating engineers submit a written report to the maintenance engineer of any work they find necessary to be done. This report is made out upon the form shown in Fig. 2, which has been made up for this purpose. The maintenance engineer confers with the operating engineer regarding the inspection and repairs of boilers and turbines, and together they arrange for the shutting down of apparatus for work to be done. No work is started on any apparatus, nor is any pipe line of the plant cut out which would in any way affect the regular routine operation without first securing the written consent of the operating engineer.

The order blank, Fig. 2, duly signed by the requestee and the operating engineer, is made in duplicate. The foreman doing the work keeps the original, it being a sort of license for him; the responsibility not being removed until this same original order has been receipted by the operating engineer who receives the apparatus back in a satisfactory condition.

The duplicate copy of the original request is kept in the "live order" file at the operating engineer's desk, so that he or the other operating engineers can at any time know of the work that is being done throughout the plant. When the work is completed this copy is signed at the same time as the original and is then put in the "completed" file.

The original order, which has now been signed by the foreman electrician or the maintenance engineer, either of whom may have requested the order, and also signed by the operating engineer receiving the apparatus back in good condition, is kept on file by the man requesting the work, as a receipt for his having successfully completed the task.

Conferences are held semimonthly in the office of the chief engineer and are attended by the operating, maintenance, testing and electrical engineers, the yard superintendent, some of their foremen and the chief and assistant chief engineer of the plant. At this meeting the chief engineer presides. Minutes of the meeting are taken and copies distributed to all those who were in attendance. In these so-called "operating council meetings" proposed changes in design, methods of procedure in any particular case and new ideas are discussed. The men have come to express their opinion freely on any matter in these meetings, and they generally have in their notebooks a collection of subjects accumulated since the last meeting, upon which they ask for decisions. Most of the decisions in connection with changes of any kind in the plant are made as the result of these discussions, so all the men in the plant who have any responsible part in its operation have the advantage of hearing of the decisions as soon as they are reached and the reasons for making them. By giving the foremen this chance to express their ideas, a great number of improvements leading to greater safety to employees, increased thermal efficiency of the plants and reductions in productive costs have come from these very men.

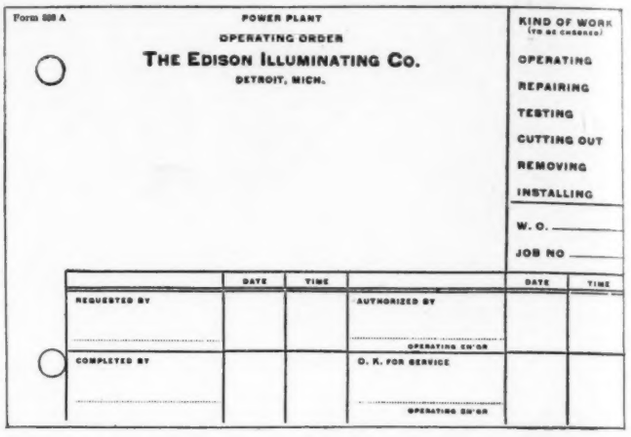


FIG. 2. REPAIR FORM USED AT DELRAY

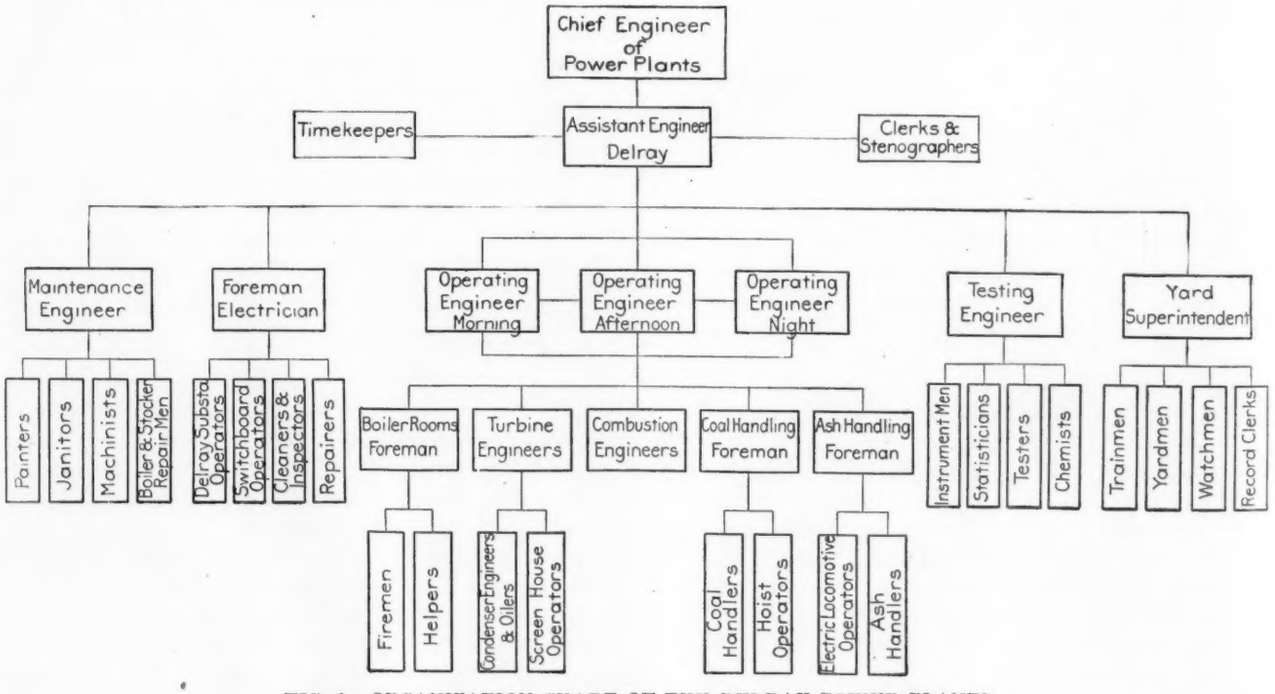


FIG. 1. ORGANIZATION CHART OF THE DELRAY POWER PLANTS

Editorials

Demonstrating the Impossible

Money and energy are often wasted demonstrating the impossible. Thousands of dollars and millions of hours have been spent developing machines which a few strokes of a pencil would have proven could not possibly go. The Goodyear Tire & Rubber Co. has just been making an extensive series of "unusually severe tests" to satisfy itself that a tire will not explode from any heat which it may acquire in use. A tire pumped up to eighty pounds standing in the cool of the garage was driven for forty miles over brick and tarred-wood pavements in the hot sun, with the result that the pressure increased "just four pounds." As tires have often been "inflated up to three hundred pounds without damage," the rise of four pounds is not serious.

With the volume remaining constant, the pressure of air varies directly as the absolute temperature. If the air in a tire were only forty degrees, and it should become heated to one hundred, the pressure would be increased but twelve per cent., or only twelve pounds if the initial pressure were one hundred pounds absolute. With the limit thus physically set for a case more extreme than any which would possibly occur in practice, experimentation seems unnecessary.

Lessons of "Near Accidents"

Operating engineers seldom need to be urged to study the details of accidents coming under their observation. The importance of avoiding future trouble incites a man to leave no stone unturned to find out just what caused the disaster, be it small or large; and while there is still room for better work in the writing of accident reports and histories, most engineers are thoroughly alive to the technical interest of actual operating troubles.

There is a class of narrow escapes from accident which is just as important for study as a distinct plant calamity. For the lack of a better name these troubles may be designated as "near-accidents," the trouble always being one which might have been a good deal worse and hence relative in its effects upon the equipment and the staff. In the strictest sense such occurrences are small accidents, but none the less are potent as lessons to discerning engineers. Every time an operating man realizes that either he or his machinery has had a "close call," conditions are ripe for just the kind of study we have in mind, occupying an intermediate place between the analysis of major operating troubles and "safety-first" surveys.

Such "near-accidents" include occurrences like a narrow escape from injury on account of the dropping of a heavy pipe wrench into the firing aisle; slight overheating of bearings due to excessive speed of a motor; ignition of waste in an open holder by a carelessly thrown match; blowing of a lighting fuse because of careless wrapping of a lamp cord around a metal support; accumulation of condensed steam from a leaky pipe joint in a cable duct line, and sluggishness of governor action due to insufficient cleaning and lubrication. On the electrical side of a generating station many occurrences fall within the class of "near-accidents," especially those due to insufficient care in approaching live circuits and terminals, temporary arcs and flash-overs caused by improper handling of switches, regulators, etc., and burnouts of minor character caused by inadequate fusing, poor mechanical contacts, insufficient insulation, and the making of wrong connections.

Such small accidents may not call for exhaustive reports in the log book, but if recognized in their full significance at the time of their occurrence point the way toward safer and better operation.

Robbing the Cradle

The committee on increase of membership of the American Society of Mechanical Engineers has been doing excellent work. How little ground exists for the assertion that the increase which it has brought about has been at the expense of robbing the cradle or of deterioration in the quality of the membership is shown by the following analysis of the last ballot. On this ballot sixty-seven members were elected, of an average age of forty-two, the minimum and maximum being thirty-two and sixty-four years. Twenty-six of these members, or about forty per cent., are college graduates. On the same ballot there were elected sixty-four juniors of an average age of twenty-four years, the minimum age being twenty-one and the maximum twenty-nine. Forty-eight, or over seventy per cent. of these, are college graduates. It would be too long to reproduce the list of positions which they occupy, but in responsibility and importance, they apparently compare very well with those occupied by the older members.

Opportunities and Favoritism

In an interesting interview on the occasion of his seventieth birthday anniversary Theodore N. Vail, president of the American Telephone & Telegraph Co., said that opportunities for young men were never so large as now, but that while these have increased, the time has come when only merit in business life wins success. Mr. Vail amplified his point of view in the following words, which may well be taken to heart by young men striving for advancement in the profession of the engineer:

"The young man who is willing to work and has ability and a good education is the one who is going ahead. There was a time when, because a person was the son of an old friend or had influence, he would be given a good position and boosted along. That day is past. Too much is involved in big business to have its affairs retarded because of a friendship. It has been discovered that one cannot run a business under the present high pressure by favoritism or nepotism. I don't mean that young men with friends are not given chances, but I say that they have to make good or get out."

If this is true in business, how much more it applies to the exact work of the engineer, dealing as he does with the application of natural laws which know absolutely no bias but which are everywhere uniform and trustworthy. This is one reason why men in engineering work are so often contented to toil with all their strength in places whose surroundings are the despair of the æsthete and who find in their daily problems an inspiration which lifts them above the plane of ordinary existence in these drab communities. Condenser leakage is just as interesting a difficulty in a plant serving a remote town in the sagebrush and alkali hinterland as it is in a populous manufacturing city of Massachusetts or Rhode Island; in fact, the necessities of the water-supply may be a great deal more troublesome and demand a higher grade of engineering ability in the latter place than in the former. The work of the engineer is in a measure impersonal in its success, just as it is to a great extent independent of geographical conditions—not that individuality counts for less, but making good is entirely outside the realms of favoritism.

Mr. Vail's requirements can be met in two respects at least by everyone—willingness to work and educational attainment. Without the first even an engineering genius is likely to be passed in the race by the slow and steady plodder whose reputation for reliability "takes" with the discriminating employer far more than spasmodic brilliancy of attainment combined with neglect of routine, and in these days of educational opportunity every ambitious engineering worker can find at hand means of advancement to planes of knowledge formerly out of reach of beginners and middle-grade men alike. As for ability, one's native endowment counts for much; but after all, incessant industry goes far toward overcoming handicaps of this kind, leading the determined seeker after advancement through sure paths to success.

Room for Greater Safety

When a power plant slides into a hole in the earth no quantity of safety devices will stop the slide, and if there are human beings in the buildings they are in great danger from many sources. Live steam is only one of the dangers. At Hudson, N. Y., where recently an earth slip wrecked a plant and five men were killed, the men were scalded to death in the power house and the boilers did not explode. This, naturally, gives rise to the thought that automatically operated valves, placed close to the boilers and arranged to close immediately upon rupture of the pipes, might have saved the lives of the men.

This could be accomplished in several ways. Upon rupture the steam velocity in the pipe line doubtless surpassed any working velocity. This increased velocity could be utilized to set off a mechanism that would quickly close the pipe right at the boilers and stop the leak. The pressure drop in the pipe line could be used similarly to furnish the shutting-off impulse. In the same way that machines are safeguarded against overspeeding, pipe lines can be closed against excessive leaking.

A device of this kind always makes a plant cost a little more, but it should be installed anyway. The window latch, a safety device against burglars, makes a house cost a little more, but it is invariably installed, although millions of them have never performed the function of keeping burglars out. The window latch cannot act in a useful capacity while there are no burglars and safety devices do not work while a plant is safe, but those are no arguments against providing them.

The recent work of the national conventions of the operating engineers sounds a deep and significant note for the thousands of power-plant owners and managers. Operating engineers have taken giant strides into the realms of engineering knowledge and skill, and the greater part of the profit has redounded to the interests of their employers. But while creditably and bravely doing their part, the engineers are heavily handicapped by their employers' indifference and lack of coöperation. In many instances the engineer is a mere drudge and a machine. There are other fields of industrial endeavor where the employers eagerly court the coöperation and confidence of their workmen; in the power-plant field this practice is almost wholly unknown. Why?

The necessity for uniform state laws is seeping into other fields than boilers, workmen's compensation, light and power rates, etc. The prevailing skepticism that it would be impossible to bring any semblance of order out of the chaos of greatly diverging state laws is, in view of the lively interest now being shown by those who believe that more uniform laws will convert many evils now existing, growing less. We have too many laws on state statute books, and the number is constantly increasing. We need not more laws but a greater uniformity in those existing.

In some ways it is gratifying to learn that a boiler-manufacturing company has said, "No, thank you!" in answer to a request to fill a large war order. "Our plant is too busy with our regular patrons," it declares. Besides, it is but natural that the very nature of a boiler manufacturer's business should make highly repellant the production of anything having an explosion as its main characteristic.

Putting heart into work is the quickest way to drive drudgery out of it. If your surroundings are not satisfactory see how much you can do to improve them.

Give the supply salesmen the glad hand, for now and then they will give you a good bit of information in return if you only let them have a chance to talk.

Bright work doesn't make an engine pull a pound more, but if it makes it look more pleasing and give more satisfaction in this way, then it is worth something.

A man should know his worth, but he shouldn't get swelled up too much about it and lose it.

The humorous side of things helps the man who can find it, to get lots of fun out of his work.

The hardest-working man is not always the best fireman, yet a good fireman must not be afraid of work.

When you change your address, please notify *Power* at least two weeks in advance, if possible, giving the old address as well as the new.

Correspondence

Centrifugal Boiler-Feed Pumps

In *Power* of July 27, p. 132[1], Mr. Richardson asks why the centrifugal pump has not made greater headway, especially in plants recently built or now under construction. There are probably several excellent reasons for not finding more centrifugals in plants that have been running some time, but it will undoubtedly be found that for the large plants now being built preference is given to the centrifugal boiler feeder where conditions permit; but the fact remains that there are many places to which this type cannot be adapted.

The application of centrifugal pumps to boiler feeding is of very recent date. It is believed that the first turbine-driven centrifugal feed pumps of any size were installed by the New York Edison Co. in August, 1906, only nine years ago. Since then boilers aggregating several million horsepower have been served by centrifugal pumps. These plants, however, comprise but a very small part of the whole number in operation. The centrifugal pump has also had to contend with the "inertia" of a possible purchaser who temporarily is willing to watch the experiments of a neighbor, while himself playing safe and installing a reciprocating unit which from long experience is known to be absolutely reliable. Unfortunately many of the centrifugal machines first put out were not.

This period has now passed and the centrifugal unit is as reliable as the reciprocating pump, but only so when properly designed for a given installation, for the elasticity of the reciprocating pump is lacking. Every centrifugal pump has one point of maximum efficiency where a predetermined discharge is effected at a definite speed and discharge pressure. When operated at any other speed, volume or pressure the efficiency will be lower. This makes the centrifugal a machine for a particular rather than general service.

It cannot discharge a small quantity of water against a high pressure in a commercially satisfactory manner. It is undesirable for boiler feeding when of less capacity than 100 gal. per min. or, say, for an installation of about 1300 hp. No data is at hand to show the comparative number of plants in operation of this or greater capacity; but probably the smaller plants are in the majority. Hence, because of the lesser opportunity of installing them, there are fewer centrifugal boiler feeders.

Some of the reasons for limiting the size of the pump to this capacity are as follows: When operating at small capacity against the pressures involved it is necessary to make the pump of many stages so as to secure the requisite pressure, and the leakage in proportion to capacity is excessive. The leakage, moreover, increases from stage to stage, and the capacity will be much less than the rated capacity of the pump. The leakage could be reduced by increasing the number of stages, thus reducing the differential pressure between each stage; but to get this within reasonable limits, the number of stages would make the manufacturing cost prohibitive for a machine that was to compete in the open market.

Another feature of importance is that the pump will probably become more or less incrusted with scale deposits from the feed water. This will happen particularly in the impeller, in which the passages are of necessity small and the openings narrow, and will tend to choke the pump and reduce the capacity. It is also highly probable that erosion will occur at the impeller tips and wear take place on the labyrinth rings, so that its efficiency would be rapidly reduced. For sizes larger than 2 in. or 2½ in., these difficulties are of relatively smaller consequence.

When the centrifugal was first introduced the thrust bearings gave trouble, but modern practice indicates that an internal hydraulic balancing device will remove the need for a thrust bearing, with its attendant annoyances.

To recapitulate: Centrifugal pumps are not found so frequently as boiler feeders because they are a comparatively new proposition and because many plants are too small to make their installation a good business proposition. Finally, being designed for some particular service, they lack the elasticity so characteristic of the reciprocating pump.

T. D. Hayes.

Troy, N. Y.

[1]See also pages 275 and 276, Aug. 24.

Plain Information Wanted

In *Power* of July 27, as its foreword, appeared a most timely article on "Helpful Hints on Gathering Knowledge." Mr. Wills, its author, wisely reasons that while "books are a man's best friends, he should be careful how he chooses them."

In our childhood days, when we were most receptive, we conquered our three R's all the more readily because they were served to us in doses that we could readily and satisfactorily digest—they were understandable. Even today we are children in our perception of truth and fact, and we would be all the more eager after knowledge of our vocation if the learned, and often incomprehensible, writers of engineering books would talk *to* us instead of over our heads. No matter how sedate our demeanor, how fixed our habits, there still lingers that "childish impulse" to desire all the simplicity of our early instruction in our attempt to broaden our useful knowledge of engineering and its ever-increasing demands on us.

It is a fine thing to be erudite, to know nearly all there is to know, but this is a gift denied most of use poor humans, whether lifelong students or merely men whose slim knowledge has been gained mainly through hard experience, supplemented by the desire to find out the "why" after having acquired the "how." But abstract knowledge and erudition are many planes above us, and practically useless; we must have concrete facts and information if we are to make headway in our attempt to learn a few useful things thoroughly and profitably.

True, some of the many books are "our friends," but there is nothing which so quickly smothers our fire for knowledge than, for instance, to purchase a "Primer of Electricity," let us call it, and on reading a few pages discover that it would take a Steinmetz to comprehend it and a course in higher mathematics to work it out.

If, in the presentation of their subjects, most of our writers would pattern after such papers as operating engineers' journals, and talk shop rather than abstruse science, their books would be as eagerly sought as are the papers. The province of the weekly and monthly papers is to record chiefly the current practice, improvements and happenings, and while they help us to travel along the royal road to learning, books are, after all, "the maps of the whole course."

Successfully to reach the man in the field, our writers should model their presentations on such works as the "Power-Plant Library," which is so written that both the beginners and the chief can understand them.

Bookmen, do not hurl broadsides of learning at us in the trenches; do not asphyxiate us with high-brow "gas." Rather, and in the vernacular, "Shoot it to us easy."

H. H. Elton.

Rosebank, N. Y.

Boiler Tests at Various Loads

Referring to my article, "Boiler Tests at Various Loads," appearing in *Power* of Aug. 17, I wish to make a correction.

I said: "A draft of 0.35 in. in the furnace is what is usually required with overfeed stokers for this quantity of coal" (23 lb. per sq.ft.).

I find that I read the wrong curve, and this should read "0.2 to 0.25-in. draft for 23 lb. per sq.ft."

Theodore Maynz.

New York City.

Blowing Out Steam Lines*

I have just been acquiring some experience in blowing out new steam pipes, having put a new plant in operation. If I ever have to erect another plant I am going to have a strainer put in the steam lines near each important unit. We hammered all the piping and blew each section out with air as it was erected. When steam was raised we blew out all lines for about four hours before coupling up to the engines but still we get scale occasionally. The worst trouble is with iron scale which has been loosened by the heating and bending process, but which hangs on for a long time after starting up before being finally dislodged, for which the erectors cannot be blamed. I think good strainers are the best safeguard for an engine and a good investment.

With regard to new equipment, I believe if builders and designers would allow a little more iron on some of their flanges it would make erection and sometimes operation a great deal easier. I have seen flanges so narrow that it was impossible to get a wrench on the nut well enough to draw the bolts up reasonably tight. It is no wonder that some men resort to the cold-chisel-and-hammer method of tightening such bolts. Sometimes flanges have the bolt holes so large that only the corners of squares on the bolt-heads catch on the edges of the holes. These are all items that make for good or poor construction and that help to increase maintenance costs. If designers had to get out and erect and operate for a while some of the machines they design, we would soon have better-designed equipment.

A. A. Blanchard.

Ringwood Manor, N. J.

*See "Blowing Out Steam Lines," p. 161, Aug. 3, also "Clean New Steam Lines," p. 889, June 29, and p. 785, June 8.

Removing Scale from Gas-Engine Cylinder

Referring to Mr. Morrison's letter in *Power* of June 22, I do not understand the reason for putting oil in with the graphite, as in all probability the oil simply floats away with the outlet water. Better results would be obtained if he would use a little common soda with the graphite.

If the circulating water is so bad in this case, why not try the effect of getting an extra tank (presuming that the water is used over again) and arrange a small evaporator around the exhaust pipe and gradually settle all the deposit out by heating the water? After once filling the tanks with water that has been treated the amount required for makeup would be very small.

E. R. Pearce.

Rochdale, England.

Minding My Own Business--Not

My own experience has been somewhat similar to that described by A. D. Palmer in *Power* of July 20, p. 95. During my early days I was very much concerned as to what the duties of an engineer should include. Should he take out and renew the boiler tubes and do the firebrick work? How far should he go in steam-fitting and plumbing? Should he take care of the belts, line up the shafting, babbitt bearings, repair and calibrate steam gages and do electric repair work, etc., besides the adjustments and repairs to engines, generators and condensing equipment? I had always been of the opinion that an engineer should be able to do most of the work enumerated, besides being somewhat of a machinist and all-around mechanic. I have since then tried out several plans of work. In one plant of which I had charge we paid strict attention to operation and called in the various mechanics needed, and confined our undivided attention to the adjustment of the machinery and the operation of the plant, so that the highest economy and best service might be secured.

At the next plant we had more help and could do all of our own repair work. This scheme proved successful in this plant. I then took a plant on the economy basis and followed the plan of calling in no outside help unless absolutely necessary. The equipment was nearly all second-hand when installed, which, as usual, called for continual repairs and adjustment, with the result that little time was left for improvements and betterments in economy. So I feel that I am qualified by such experience to say that while it is the duty of an engineer to save his employer's money, he very often does make a fool of himself by suggesting or by working up schemes to reduce the cost of operation which in time only serve to make his job unbearable. The great trouble with most of us is that we allow our enthusiasm to run away with us

and attempt too much. We would no doubt come out better in the long run by going very slowly in making recommendations, first carefully studying the scheme. I am and always have been an enthusiast for economy, yet uninterrupted service is a big factor, and too much attention given to economy may result in the neglect of many seemingly small things which in time nullify the saving made in other directions.

My present plan is the one I intend to pursue in the future—look the situation over carefully, find out what I must do, and not introduce any more complications than are absolutely necessary gradually to tighten my grip, but I will make sure beforehand that they will tighten my grip. The improvements, selection of apparatus, etc., should be left to the consulting engineer; then if it should prove faulty, the operating engineer is in a defensible position.

In conclusion, the engineer will usually do best to attend to his own business, which should include only such duties as pertain to the everyday operation of the plant. He will be quite wise in calling in expert repairmen, as well as the consulting engineer, when any changes in equipment are contemplated, and decidedly so if any new equipment is to be installed.

WALDO WEAVER.

Beacon Falls, Conn.

Paper Mill Power Plants

In *Power* of June 1, p. 758, W. H. Holmes says that he has not heard anything from engineers in paper-mill power plants for a long time. I have noticed this and concluded that the chief reason was that most engineers in paper-mill plants work from 11 to 13 hr. per day, seven days per week; hence they have little time for anything else. Great improvements have been made in most paper-mill steam plants during the last ten years, perhaps to a greater degree than in any other line. Engines were invariably run noncondensing and the exhaust wasted, while live steam was used to dry the paper and heat the water and paper stuff in the beaters.

The equipment was generally similar to that in sawmills, second-hand and patched up in a way that would not be tolerated now. The engine cylinders were often so badly worn that the rings had been ground to pieces, resembling ball bearings or shot, and deep grooves were worn in the bottom of the cylinder. The following are some sample cases: A corliss engine piston was packed with piston-rod packing and operated in this way for several weeks. This engine was also fitted with a throttling governor—the knock-off cams and dashpots had long since been discarded.

When the cutoff valve on a Buckeye engine broke the pieces were removed and a piece of heavy sheet iron cut nearly to the same shape served in its place. The lubricator pipe broke off on Friday night, but the engineer did not feel like working the following Sunday, so the engine had to run the following week without cylinder oil, except what could be introduced by way of the indicator piping. A 12x21-in. engine was used to drive a paper machine and the exhaust was used to dry the paper. The condensation accumulated until it backed up into the engine, knocked the head out and ruined the cylinder. A new cylinder was put on and operated for more than two years before the setting of the valves was tested by the use of an indicator. This cylinder was also treated to a water test, the piston being wrecked this time and the rod bent, after which the proper drains were installed on the driers and exhaust line, and no more trouble was experienced. One night the water and exhaust pressure backed up on the 20x42-in. corliss engine until the pressure on the exhaust side was about equal to the steam pressure, under which condition the engine naturally could not pull the load. The relief valve exhausted directly to the atmosphere. The 4-in. gate valve leading to the driers was often entirely closed and with all available iron of convenient size hung on the relief valve. The result was that the exhaust pressure would rise until the engine slowed down, and the whole engine shook and let out some pitiful groans.

The coal question was the biggest joke of all in paper mills in those days. Many of them purchased whatever was available at the lowest price. They would often buy shipments that had been rejected somewhere else, usually the cheapest coal having the greatest ash content. It was a common practice to clean fires every three or four hours. However, in some mills once on each 12-hr. shift was the rule, no matter how dirty the coal, with the result that the steam would frequently drop to 60 or 70 lb., and most of the load would have to be dropped for a while.

Sometimes return-tubular boilers were fired for a week at a time, with water running out at the tube ends at the rear so fast that the water level could barely be maintained. The orders were to fire them as long as the water could be kept in sight.

One boiler had been operated with two cracks in the front head (one crack on each side of the manhole) for some time, when suddenly the gasket blew out. A new gasket was put in, the boiler filled and fired up. The gasket blew again when the pressure got up to 30 lb. This performance was gone through three times, when a new crack was discovered at the top of the manhole. The superintendent said that that would not hurt anything, that no time should be lost in arguing the case or getting the boiler in service. The engineer then told the firemen that the boiler would surely blow up if they ever got it up to 100-lb. pressure. That settled it. The whole outfit decided to quit; so the superintendent had the head patched.

Boilers were invariably fed with cold water. Globe valves with composition disks were thrown away when they leaked instead of new disks being put in. At the week-end the boilers were fired until 5 o'clock Sunday morning, then cut out and a 1-in. vent pipe opened. When the pressure got down to 30 or 40 lb. the blowoff was opened and by 9 o'clock the boilers were being washed and the redhot ash cleaned out. Sunday afternoon was consumed in rolling tube ends and patching the fire walls—a strenuous day. These are but a few of the many wasteful, inefficient and dangerous conditions which existed only eight or ten years ago, but the conditions are entirely different today. Now the very best equipment is installed. Probably no other industrial power plant can show a more rapid improvement, and the daily report is in evidence in all uptodate plants. We should hear more often from paper-mill engineers, as more things happen in a paper-mill plant in a week than in some others in a month.

WALDO WEAVER.

Beacon Falls, Conn.

Ground Caused by Vibration

William E. Dixon's letter on "An Elusive Ground" brought to mind one that troubled me for a week some years ago on a 250-volt direct-current generator.

It seemed to ground only when overloaded, and only for an instant at that. We were unable to locate the trouble until one day when the load was swinging from 300 to 450 hp. I was standing by the switchboard with a blower cooling fuses that were at the point of melting, when I heard a noise in the generator that sounded like the tearing of canvas. I immediately exchanged places with the oiler and searched for the noise. When it occurred again I noticed a small flame issuing from the armature to a field core, but this only happened three times, and only that one day. The following day I took out the coil and core and found a wire chafed so that it grounded at times from vibration. A little tape and varnish cured it.

B. C. White.

Yonkers, N. Y.

Temperature of Compression in Refrigeration Machines

In reading the article by Mr. Thurston on "Operating a Refrigerating Plant" there is one sentence with which the writer cannot agree, namely: "The machine should be run warm enough so that the jacket water is at least lukewarm, and the discharge temperature of the machine should not be much less than 180 deg. F. for a head pressure of 150 to 180 lb., and 200 to 225 lb. may sometimes show better efficiency."

This statement is so misleading that neither the beginner nor the old-timer who is not proficient is benefited by it. Mr. Thurston uses the temperature of 180 deg. F. for the pressures of from 150 to 225 lb., or the same temperature through a range of 75-lb. The heat of compression is governed by three factors—the back pressure, the condenser pressure, and the quality of the suction vapor. The latter factor influences the heat of compression again in three ways—first, it may be just saturated with heat, or, in other words, of 100 per cent. quality; second, it may be highly superheated, or overloaded with heat; third, it may be loaded with liquid, or underloaded with heat.

If the back pressure of the saturated vapor is constant and the head pressure increases, then the discharge temperature increases. The rate of increase of temperature is nearly 0.9 deg. F. for every pound increase of the discharge gas pressure. But if the pressure of the saturated suction vapor increases and the discharge gas pressure is constant, then the temperature of the discharge gas will decrease. If the suction vapor happens to be superheated, the temperature of the discharge gas is increased by approximately the same amount as the suction gas is superheated. If, on the other hand, the suction vapor is loaded with liquid, then the temperature of the discharge gas is lowered in proportion to the amount of the liquid contained in the suction vapor.

Of course these temperatures cannot be guessed. To illustrate: The suction pipe may be frosted up to the compressor and still the vapor therein may be 25 deg. F. superheated, which causes a loss in the efficiency of the compressor of over 6 per cent. The only proper guides in getting the most work out of the compressor are thermometers in the suction and the discharge pipes close to the compressor.

William Schliemann.

New York City.

The Sawmill Power Plant

It is not so far back in the history of lumber manufacturing when the qualifications for the engineer at a sawmill involved more of the elements of rough and ready than of the science of fuel and steam economy. Yet today some of the best power-plant equipments of the country are to be found in connection with sawmills.

A little more than a decade ago—during the great World's Fair at St. Louis, to be exact—the writer, in discussing the question of sawmill and power-plant equipment with a prominent manufacturer of valves and steam fittings, was told that the company did not concern itself with the sawmill trade because it was not a discriminating trade where quality and modern appliances counted for much against the cheaper offerings or the item of first cost.

All power-using industries show contrasts in the size of the power plants and variations in efficiency; but nowhere perhaps is this contrast more marked than in the sawmill power plant of today, because while some have been very highly modernized within a few years, others still belong to the rough and rugged class, using comparatively low steam pressure and plain, slide-valve engines, and the engineer is more of a laborer than a skilled worker or scientific thinker.

Yet a brief outline of the equipment contracted for by one of the new plants of the year in the South will give an idea of the modern sawmill power plant.

The boiler-house equipment consists of four rated 500-hp. vertical water-tube boilers, an open feed-water heater, two large plunger-type boiler-feed pumps and one 12x 11x10-in. air compressor.

The engine-room equipment consists of a 2000-kw. condensing, turbine-driven, alternator and a 125-kw. auxiliary generator set for lighting, and some small motors.

J. Crow Taylor.

Louisville, Ky.

Topics for Discussion

Many topics are, and have been, discussed in *Power's* pages, generally suggested by engineers, along the lines which interest them most. Frequently old questions come up in a different way; besides there are new boys taking a hand in the old game continually, many of whom hesitate to ask questions or write of their experiences.

Allow me to suggest a few topics for discussion: Compulsory Government inspection of boilers, abolishing fees for same; uniform engineers' examinations and licenses throughout the United States and Canada; uniform laws governing the maximum hours to constitute a day and a week's work for engineers; advantages of having prices attached to advertised and catalogued supplies whenever possible.

The foregoing are only some samples to illustrate my suggestion and to "start something" along this line.

James E. Noble.

Toronto, Ont.

Inquiries of General Interest

Maintaining Proper Water Level in Pump Air Chamber—How can the water level in a pump air chamber be regulated?

W. R. C.

For keeping the water level at the proper height a pump air chamber should be provided with a glass gage and have a pet-cock near the top of the air chamber for withdrawing, from time to time, any excess of air.

Different Names for Carbonate of Soda—What are the different commercial names of carbonate of soda used for removing scale from boilers?

H. M. C.

Carbonate of soda is also known by the names of soda ash, Scotch soda, soda crystals, sal soda, washing soda, concentrated crystal soda, crystal carbonate of soda, black ash and alkali.

Detecting Leakage of Ammonia Gas—How can small leakages of ammonia gas be detected?

C. R. B.

One of the most convenient and reliable means for locating a leak is to burn a small quantity of sulphur at the end of a stick of wood about 18 in. long. Where the sulphur fumes come in contact with the ammonia gas a white vapor will be observed.

Cutting Glass Tubing for Orsat—How is thin glass tubing cut to desired lengths for use in an Orsat?

C. R. B.

Thin glass tubing is cut by making a scratch around it with a sharp three-cornered file, then grasping the tubing firmly in both hands, with the thumb nails together and opposite the scratch, the tube is to be partly pulled and partly bent apart, when it will break squarely at the scratch.

Ratio of Liquid Gasoline to Air in Gasoline Engine—What should be the ratio of liquid gasoline and air, by volume, to give the best results in an ordinary gasoline engine?

C. E. B.

This would vary somewhat with the quality of gasoline and the carburetor adjustment. With an average grade of gasoline, one pint would require about 150 cu.ft. for theoretical combustion. Allowing an excess of 25 per cent, of air would make the requirements 187.5 cu.ft. of air per pint of gasoline.

No Advantage in Connecting Siphon to Pump Suction—Will the suction pressure of a pump be increased by connecting its suction with the rising leg of a siphon taking water from the same level?

E. C. H.

It would not be increased, as the action would be the same as that of two pumps connected into a common suction line. Neglecting any difference of pressure due to difference in friction, the suction pressure at the point where the common suction pipe branched to each pump would be the same as the suction pressure at the same level in an independent suction pipe.

Waterproofing Blueprints—What is a good method of waterproofing blueprint drawings?

W. H. R.

Blueprint drawings made on paper can be readily waterproofed by placing them between pieces of muslin that have been saturated with paraffin and passing a hot smoothing iron over them, thus causing enough paraffin to be absorbed by the drawings to render them impervious to water. The paraffined cloths can be prepared by soaking pieces of muslin about 12 in. square in molten paraffin obtained by melting down paraffin candles. When thoroughly saturated the cloths should be hung in a warm place to drain and dry and when thus prepared can be used a number of times.

Use of Vacuum Pump With Jacketed Kettle—Where exhaust steam is used for heating water in a jacketed kettle, could the water be heated to a higher temperature if a vacuum pump were connected to the exhaust outlet of the jacket?

B. R. L.

By discharging to a vacuum pump the air will be removed, and although the temperature of the steam will be slightly reduced, the water of the kettle should be heated to a higher temperature on account of more positive circulation of the steam. Care should be observed, however, that no higher vacuum is carried than necessary for best results, as the temperature of the steam would be unnecessarily reduced and the steam would have a tendency to short-circuit in its passage through the jacket.

Increasing Temperature of Feed Water with Increase of Back Pressure—With a closed exhaust-steam feed-water heater and 2 lb. back pressure on the engine, the temperature of the feed water is 205 deg. F. The boiler pressure is 100 lb. and the m.e.p. of the engine is 42 lb. Would it pay to increase the engine back pressure sufficiently to raise the feed-water temperature to 212 deg. F.?

J. C. R.

Assuming that the efficiency of the feed-water heater is such that the proposed increase of feed-water temperature would require an equal increase in the temperature of the exhaust, then it would not pay to increase the back pressure, for there would be more heat needed for generation of additional steam required by the engine than the additional heat recovered in the feed water. A pound of steam at 100 lb. gage, or 115 lb. absolute, contains 1188.8 B.t.u., and with feed water at 205 deg. F. each pound of steam generated requires 1188.8 — (205 — 32) = 1015.8 B.t.u., and with feed water at 212 deg. F., or 7 degrees higher, each pound of feed water for conversion into steam would require 1015.8 — 7 = 1008.8 B.t.u. The temperature of the exhaust at a pressure of 2 lb. above the atmosphere is about 219.4 deg. F., and if increased 7 degrees the temperature, 226.4 deg. F. would correspond to a back pressure of about 4½ lb. above atmospheric pressure, or an increase of 2½ lb. back pressure. The additional steam required by the engine would be substantially the same as for an increase of the m.e.p. from 42 to 44½ lb. m.e.p. with 2 lb. back pressure, and as the economy per pound m.e.p. would be practically the same, then for development of the same power the heat required would be $\frac{1008.8 \times 44.5}{1015.8 \times 42} = 1.052$ times as much as with feed water at 205 deg. F. That is, about 5 per cent. more fuel would be required.

Increase of Boiler Pressure to Compensate for Loss of Vacuum—With a Corliss engine supplied with steam at 135 lb. boiler pressure, cutting off at ¼ stroke and running condensing with 26 in. of vacuum, if the vacuum should be lost what would the initial pressure have to be to develop the same power running noncondensing with the same point of cutoff?

J. J. B.

By referring to a table of "Mean Pressure per Pound of Initial, with Different Clearances and Points of Cutoff," such as given on page 115 of Low's "Steam Engine Indicator," and assuming that the engine under consideration has 5 per cent. clearance, it may be seen that the average pressure per pound initial (absolute) for ¼ cutoff would be 0.6258 lb. Hence for an initial pressure of 135 lb. gage, or 150 lb. absolute, the average (forward) pressure would be 0.6258 × 150 = 93.87 lb. per sq.in. absolute. The back pressure due to 26 in. vacuum would be about (30 — 26) × 0.491 = 1.964 lb. per sq.in. absolute, making 93.87 — 1.964 = 91.9 lb. m.e.p. for the theoretical diagram without allowances for any falling of pressure during admission rounding off at cutoff or release or reduction of the m.e.p. by compression of the exhaust. To develop the same power the mean effective pressure would have to be the same whether running condensing or noncondensing.

With loss of the 26 in. vacuum and allowing that the back pressure of the exhaust would be 2 lb. above atmosphere and that the actual diagram would be the same percentage of the theoretical as when running condensing, then the mean forward pressure would have to be 91.9 + 2 + 14.7 = 108.6 lb. absolute. With cutoff at ¼ stroke, each pound of initial, as before, would develop 0.6258 lb. mean pressure. Hence the initial pressure for running noncondensing would have to be 108.6 ÷ 0.6258 = 173.53 lb. absolute, or 173.53 — 14.7 = 158.83 lb. per sq.in. boiler pressure.

[Correspondents sending us inquiries should sign their communications with full names and post-office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Flow of Electrical Energy

By R. A. Philip*

SYNOPSIS—A graphical method of representing the flow of energy is described and pictures are drawn showing the functions of generators, motors, transformers, transmission lines and other parts of the electric distributing system in terms of the flow of energy through them.

The flow of a material fluid, such as water or air, through the pipes which transmit it may be shown as a ribbon whose varying width represents variations of the current. A similar picture may be drawn of the transmission of power. While this is a general method of picturing the transmission of power it is especially useful in illustrating the meaning of terms used in electrical-power transmission by alternating currents, such as wattless current, synchronous condenser and induction generator.

Although energy may be transmitted by using a current of water or a current of electricity the energy itself is neither water nor electricity; the water or electricity is but a medium of transmission. Similarly the motion which constitutes the flow of water or other mediums is not the motion which constitutes the flow of energy. The medium may be, and often is, used over and over again. The moving belt goes forward on the slack side and returns to the driving pulley on the tight side; the water goes out in the pressure pipe, and may return to the pump through the suction pipe; the electricity goes out on the positive wire and returns to the generator on the negative wire. Just as much belt, water, or electricity comes back as goes out but the transmitted energy moves forward only. In fact, the direction in which the belt, water or electricity moves can be reversed without reversing the direction in which energy is transmitted, or vice versa. Therefore, if energy is transmitted by a flow of water or of electricity, a picture of the flow of energy will not be at all identical with a picture of the flow of the transmitting medium even though the same principles may be used in representing each kind of flow.

Energy is the product of motion and pressure, therefore, if motion and pressure both reverse the flow of energy is not reversed, on the principle that the product of two negatives makes a positive. The reversal of the motion of the reciprocating parts of a steam engine does not reverse the motion of the energy which flows forward from the steam pipe to the shaft during the backward as well as the forward stroke.

With uniform motion or flow, the amount of energy transmitted is equal to the product of the motion by the pressure. The same formula holds for reciprocating motion and alternating flow provided it is understood that by motion and pressure is meant mean motion and mean pressure.

The transmission of power by electric current which alternates in direction follows the same principle as the transmission by reciprocating mechanical motion, namely the reversal of the direction of the electric current does not reverse the flow of energy because the pressure is simultaneously reversed. When the motion and pressure reverse simultaneously they are said to be in phase. Alternating motions or currents when in phase with their corresponding alternating pressures are practically equivalent to uniform motions or direct currents for the transmission of power.

Accelerating Power

It may happen that while the motion and pressure are both reciprocating or alternating, and at the same rate, they fail to reverse simultaneously. The difference in time of reversal may be very small but it cannot be greater than a quarter of a cycle. When motion and pressure reverse a quarter of a cycle apart any further change in either direction brings the times of reversal closer together. For example, two cranks on the same shaft have their respective dead points as far apart as possible when set at 90 deg. Motion and pressure are then said to be in quadrature and each reverses when the other is at a maximum.

*From a paper presented at a joint meeting of the Chicago Section, American Institute of Electrical Engineers and the Western Society of Engineers at Chicago.

Under these conditions motion and pressure instead of being positive and negative simultaneously, thereby always giving a positive product, are of the same sign but half the time; so that their product is half the time positive and half negative. This change in sign of the product, that is of the power, indicates a reversal of its direction of flow. Where motion and pressure are in quadrature the energy flows forward and backward instead of moving uniformly forward. The average of the forward and backward flow is zero so that such an alterating flow of energy does not constitute a transmission of power in the ordinary sense.

The phenomena of motion and pressure in quadrature occurs wherever a mass moves with a reciprocating motion. The motion is that of the mass and the pressure that required to accelerate it. The power corresponding to their joint effect may be called accelerating power.

The product of the mean velocity by the mean presssure, where motion and pressure are in quadrature, is an amount of power equal to the maximum value which the accelerating power attains during a cycle. The momentary flow at all times is proportional to this maximum. As the flow alternates in direction, giving an average value of zero over the cycle, it is convenient to use the maximum value as a measure of the flow when considering it in connection with associated flow of energy over one or more complete cycles.

For reciprocating motion, the product of mean velocity by mean pressure is the transmitted power if the two quantities are in phase but is the accelerating power if they are in quadrature.

Accelerating power is evidently always necessary where reciprocating motion is maintained. On the whole, the accelerating power neither adds to, nor subtracts from, the true power transmitted. It may exist where there is no true

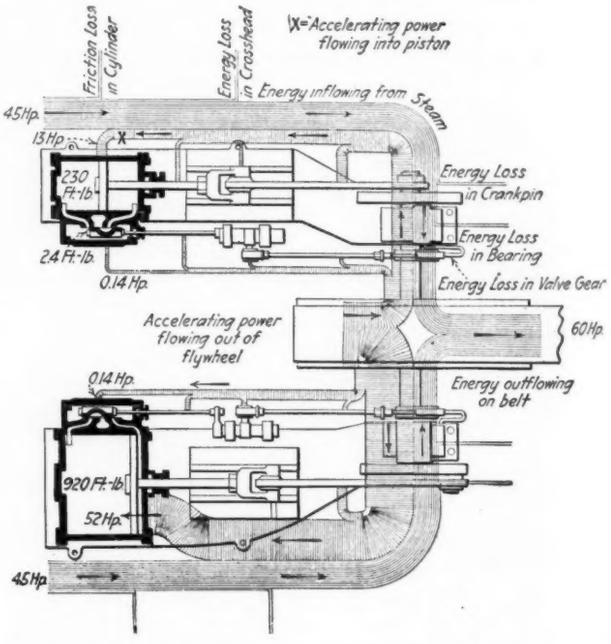


FIG. 1. FLOW OF ENERGY AND ACCELERATING POWER THROUGH ENGINE

power transmitted and for a given amount of true power the accelerating power may be greater or less. The steam engine, containing reciprocating parts, furnishes an example of the transmission of accelerating power. Consider a steam engine with steam shut off and running due to the momentum of the flywheel. Aside from any effects of friction or of compression in the cylinder, the reciprocating parts, the piston for example, must be accelerated from rest to a maximum velocity, then retarded and brought to rest again in each stroke. These accelerations require forces which must be transmitted to the piston from the flywheel through the intervening parts such as the piston rod. The reciprocating parts are therefore transmitting accelerating pressures and at the same time are

in active motion. However, it will be found that the motion of the rod reverses at the time when the pressure in it is a maximum and that the pressure reverses when the velocity is a maximum. That is, motion and pressure are in quadrature. The flywheel is giving out power and accelerating the piston during half the time and during the other half the process is reversed. It may be said that the flywheel and the piston

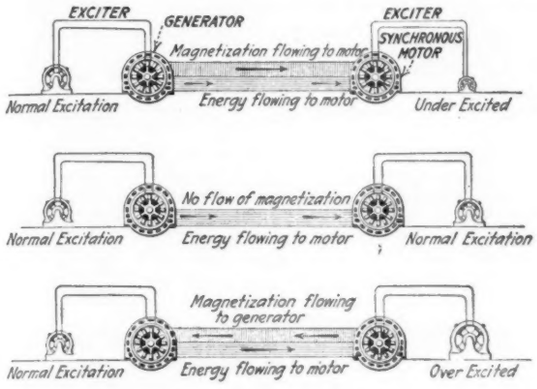


FIG. 2. FLOW OF ENERGY AND MAGNETIZATION AT VARYING EXCITATIONS

are interchanging accelerating power which alternates in direction.

To make a picture of the flow of accelerating power a second ribbon may be drawn of width equal to the accelerating power, that is the product of the mean force by the mean velocity. To distinguish between the two ribbons that for energy transmission will be shaded longitudinally and that for accelerating power laterally; see Fig. 1. Arrows have been placed on the energy-flow ribbon to indicate that energy is continually passing a given point in one direction. With such a flow the total quantity of energy increases cumulatively with the time. The flow of accelerating power alternates in direction so that arrows to represent the successive instantaneous flows would point equally in both directions.

Magnetizing Power

What has been said of mechanical motion and pressure when in quadrature applies also to electric currents and pressures. As reciprocating motion necessitates acceleration of matter and that requires the application of accelerating power, so alternating electric currents necessitate the acceleration of electricity and that also requires a similar kind of power. Mechanically, the accelerating power is stored intermittently as kinetic energy in the reciprocating mass, while electrically, the power is correspondingly stored in the alternating magnetic field of the moving electricity.

Electric currents in quadrature with the electrical pressure have been called idle or wattless currents because they transmit no power in the ordinary sense and the product of these currents by the pressure has been called wattless power for the same reason. When the magnetism is uniform in direction the magnetization is produced once for all at the beginning and no further magnetizing power is required.

A permanent magnet or an electromagnet excited by direct current may be regarded as a reservoir of magnetism just as a uniformly moving flywheel is a reservoir of energy. The magnets used in direct-current electrical machinery are of this type; therefore, except at the instant of starting no magnetizing power is used.

A permanent magnet may be compared to a frictionless flywheel which will run indefinitely when once started. But it should be noted that such energy adds in no way to the stored energy of the flywheel. A direct-current electromagnet is similar to a flywheel having shaft and bearing friction, the field current or exciting current merely overcoming electrical friction.

Electric machines absorb or give out mechanical energy because of attraction or repulsion of their constituent magnets. Alternating-current machinery such as ordinary generators, synchronous motors and synchronous converters contain both direct and alternating-current magnets. while other important electric machinery such as transformers, induction motors, induction regulators and induction generators contain alternating-current magnets only.

A machine containing both direct- and alternating-current magnets may either give out or absorb magnetizing power. A machine containing alternating-currrent magnets only can also give out or absorb magnetizing power if provided with a suitable commutator.

Magnetizing power being but an electrical variety of accelerating power its flow may be shown by a similar picture. A ribbon may be drawn for it with a width equal to the product of the mean current with the mean potential. Arrows may be placed on the ribbon to show the direction in which magnetization has been displaced. The demagnetizing of the field magnets of an alternator and the magnetization of the fields of an induction motor being proportional to the magnetizing power, and due to its flow, there is a natural basis for describing the flow as being from the point where demagnetizing takes place to the point where the magnetism reappears. This displacement of magnetization, like the transfer of energy from flywheel to piston, is a transient change which occurs when the flow begins but the displaced magnetization is only prevented from returning to its original state of equilibrium by the continuance of the flow of magnetizing power. The flow of magnetizing power is therefore not a cumulative flow, and if constant, does not further deplete the magnetization of the source from which it springs nor build up an indefinite amount of magnetization at its terminus.

Induction Motor and Induction Generator

An induction motor contains alternating-current magnets only, and therefore, must receive magnetizing power from some external source. The motor receives from the generator two independent kinds of power. The ordinary flow of energy through it is similar to that through a direct-current motor and requires no further comment. The magnetizing power which flows into the motor and goes no further is the peculiar feature. It does not vary much from full load to no load.

An induction motor like other motors is reversible in its function and may operate as a generator and is then called an induction generator. However, the flow of magnetizing power does not and cannot reverse. An induction generator cannot produce magnetizing power. The induction motor is a reversible machine as regards the flow of energy but not as regards the flow of magnetization. This explains why one induction motor operated as a generator cannot operate another as a motor unless some other machine is also connected which is capable of furnishing the magnetizing power for both machines. It also shows why it may be advantageous to forego the simplicity of the ordinary induction motor and add a commutator so that the inward flow of magnetization may be reduced, eliminated, or reversed.

Synchronous Motor and Alternating-Current Generator

An alternating-current generator can operate as an alternating-current motor and is then called a synchronous motor. The synchronous motor differs from the induction motor in being completely reversible, that is reversible as regards the flow of magnetization as well as of energy. Where an alternator transmits power to a synchronous motor there are three cases as shown in Fig. 2.

The simplest case is where, as in direct-current transmission, no magnetizing power is required. Each machine has its magnetization furnished locally by direct currents. The equality of excitation is indicated in the figure by drawing the exciters of the generator and motor the same size.

Above this is shown the case where magnetization as well as energy is being transmitted from the generator to the motor. This indicates that the motor has insufficient magnetization; it is therefore said to be under-excited. The less the direct-current excitation of the motor, the greater the magnetizing power absorbed by it. This magnetizing power produces a useful magnetization in the motor just sufficient to supplement the inadequate direct-current magnetization. If the direct-current excitation decreases, the magnetizing power increases, so that finally, if the direct-current magnetization fails entirely, the magnetizing power alone may furnish approximately normal magnetization. A synchronous motor may, therefore, run without direct-current field excitation; in fact, this principle is used in starting synchronous motors and converters.

An unexcited synchronous motor is, like an induction motor, reversible in regard to flow of energy and may be used as a generator. However, an unexcited generator or motor must absorb and cannot produce magnetizing power. Therefore, an unexcited generator cannot be used to run an unexcited motor unless there is some other source of magnetizing power adequate for both generator and motor.

At the bottom of the figure is shown the case where the motor has an excessive amount of magnetization or is over-excited. The magnetizing power now flows from the motor to the generator. The effect of this flow is to demagnetize the motor, the amount of flow being just sufficient to bring the magnetization of the motor down to equality with that of the generator.

Where several alternating-current machines having direct-current excitation are connected together, the increase in the excitation of any one machine tends to raise its voltage but this tendency is counteracted by a magnetizing current which flows away from it to the other machines, demagnetizing it and magnetizing them. A considerable increase in excitation of one machine, therefore produces a smaller though wide-spread increase in magnetization of all the machines. Con-

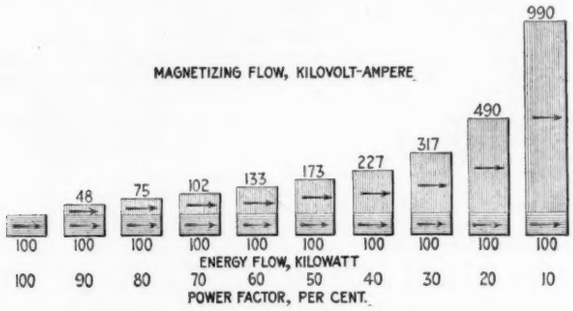


FIG. 3. RATIO OF MAGNETIZING FLOW TO ENERGY FLOW AT DIFFERENT POWER FACTORS

versely, a decrease in excitation of one machine causes an inflow of magnetizing power and a corresponding reduction in the voltage of the whole system. This condition holds whether the machines are all alternators or all synchronous motors or a mixture of the two.

Consequently, increasing the excitation of one of two alternating-current generators will not shift load, and an alternator may continue to carry its full load even if its excitation is lost. Raising the voltage at one power house will not shift the load and the voltage may be higher at the delivery end than at the generating end of a transmission line. It is true that such increasing of excitation and raising of voltage does shift the flow of power but it is the flow of magnetizing power only, not the flow of energy.

Synchronous Condensers—Their Functions

In an alternating-current generator under full load and over-excited, as the load is reduced, the energy flow decreases, stops, and reverses. As the excitation is supposed to remain unaltered the outflow of magnetizing power is practically unaffected by these changes of load by which a generator has become a motor. The transition stage between motor and generator operation presents the peculiarity that the machine though neither a motor nor a generator still produces magnetizing power. This feature is of such importance that the machine when so operating has a special name, being called a synchronous condenser.

The synchronous condenser can be used to produce the magnetizing power required for operation of induction motors or induction generators or for starting unexcited synchronous motors, or in fact for producing all or any part of the flow of magnetization required for a transmission system. The amount of magnetization produced is under control, depending on the amount of excitation. The figure shows that with decreased excitation the flow of magnetizing power eventually ceases and that a further decrease reverses the flow.

Where both motions and pressures are mechanical the transforming device is called gearing, where one pair is mechanical and the other electrical it is called a motor or generator, and if both are electrical it is called a transformer.

While energy flow and magnetizing flow can be considered to exist in the same circuit practically independently, there are not two distinguishable currents of electricity in the same wire. However, on comparing the composite current with the composite pressure it is found that the times of reversal are no longer either simultaneous nor in quadrature. Whatever the difference in phase, the total effect of the current and pressure can be analyzed into two parts, one giving energy flow only and the other magnetizing flow only.

The product of current and pressure is power, the kind of power depending upon the phase. Disregarding the phase, which is often unknown, the product is called apparent power. When the phase of the two quantities is the same the apparent power is the same as the energy flow; when the phases are in quadrature it is the same as magnetizing flow. It is found that the square of the apparent power is equal to the sum of the squares of the energy flow and the magnetizing flow.

Power Factor and Lagging and Leading Currents

Power factor expresses the relation between energy flow and apparent power. It is the number of kilowatts of power per kilovolt-ampere apparently transmitted. When the power factor is fixed the relation between the magnetizing and energy flows is also fixed. If the power factor is constant the magnetizing and energy flows can only increase or decrease proportionally.

Fig. 3 shows the relation between the flow of energy and the flow of magnetization at various power factors. The two flows are equal for a power factor of $1/\sqrt{2} = 71$ per cent. With increasing power factors the proportion of magnetizing flow diminishes until it vanishes at unity power factor while with decreasing power factors the proportion of energy flow diminishes and it becomes zero at zero power factor.

While the magnetizing power is relatively less at low than at high power factors, an increase in power factor does not necessarily mean that the magnetizing power has decreased. Thus, in an induction motor, the power factor is higher at full load than at no-load, nevertheless the magnetizing power is also greater. The increased power factor results from a great increase in energy flow accompanied by a small increase in magnetizing power.

The terms "lagging" and "leading" indicate the relative direction of flow of the two kinds of power. If they flow in the same direction the current is said to be lagging, if in opposite directions, leading. If the current is lagging it may be changed to leading by reversing either but not both of the flows. If a synchronous motor is under-excited the current is lagging. Increasing the excitation makes the current leading because it reverses the flow of magnetization while the flow of energy is not affected. If, however, the excitation is not increased but mechanical power is applied to drive the motor as a generator, the current also becomes leading because the flow of energy has been reversed while the flow of magnetization is not changed. If the excitation is increased and mechanical power is also applied, the current remains lagging because both flows have been reversed.

Calculations for Branched Circuits

Where a circuit branches, say from one generator to two motors operating at different power factors, the determination of the power factor of the generator from that of the motors looks rather complicated. The same problem is extremely simple if viewed as the division of two kinds of currents, each into two branches.

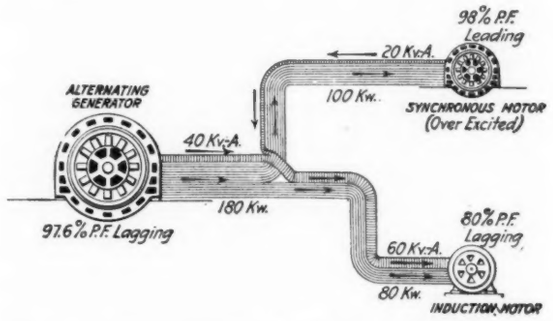


FIG. 4. REPRESENTING POWER FACTORS OF A BRANCHED CIRCUIT

For example, a generator supplies an induction motor taking 80 kw. at 80 per cent. power factor lagging and a synchronous motor taking 100 kw. at 98 per cent. power factor leading. It is evident that the generator supplies the sum of 80 and 100 kw., but it is not obvious that its power factor is 97.6 per cent. lagging. Fig. 4 shows that this complicated relation of power factors is merely a roundabout way of saying that the induction motor takes 60 kv.a. of magnetizing power while the synchronous motor gives out 20 kv.a.; therefore, the generator must give out the difference of 40 kv.a.

From these elements a picture may be drawn of the flows of energy and magnetization in any transmission and distribution system. The ribbons show graphically the equality between inflowing and outflowing magnetization. A single

flow of energy may have associated with it two or more separate flows of magnetization as shown in Fig. 5. Here a synchronous condenser forms a local source of magnetization for the induction motors at the end of a transmission line, thus saving the losses of transforming and transmitting this flow as well as performing other useful functions. The generator is shown as furnishing the magnetizing power for motors in its vicinity. Water power transmission systems usually have little load at the generating end and there are

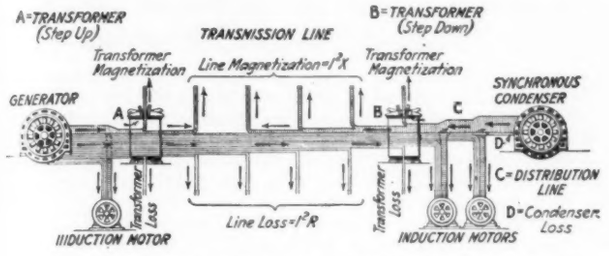


FIG. 5. FLOW THROUGH TRANSMISSION LINE

indications that a normal method of operation of such systems is to have the source of magnetization at the receiving end. When the flow of magnetization is in the opposite direction to the flow of energy at full load, the voltage drop due to the load is decreased, and the regulation is improved.

The Montana Power Co., operating throughout western Montana and northern Idaho, had assets of $84,554,609 at the beginning of 1915, a gain of approximately $6,000,000 over the total at the opening of 1914, according to figures just issued. The Great Falls Power Co. and the Thompson Falls Power Co., subsidiaries of the Montana Power Co., have entered into contracts with the Chicago, Milwaukee & St. Paul Ry. for the electrification of about 430 mi. of its main transcontinental line from Harlowtown, Mont., to Avery, Idaho, and for electric power to operate the same.

Under these contracts, which cover a period of 99 years, to go into effect on or before Jan. 1, 1918, the railway company is bound to take and pay for 20,000 kw., about 26,500 hp., and has taken an option on additional power to the extent of 30,000, kw., about 40,000 hp., which option must be exercised one-half in five years and one-half in 10 years; but not less than one-half the amount under option must be taken.

On Aug. 11 water was let over the spillway of the gigantic dam, which the Montana Power Co. has been building for the past three years for its hydro-electric plant at Big Falls on the Missouri River, 14 mi. from Great Falls. The dam alone cost about $5,000,000. Subsidiary companies of the Montana Power Co. are the Butte Electric & Power Co., the Madison River Power Co., the Billings and Eastern Montana Power Co., the Missouri River Electric & Power Co., the Great Falls Water Power & Townsite Co., and the Montana Reservoir & Irrigation Co.

Misplaced Credits in Equipment Tables—In the table of principal equipment accompanying the article entitled "Power Plant of the Granby Co.," in "Power" of July 6, it is stated that a 10-ton crane was furnished by the Whiting Foundry Equipment Co. The crane was supplied by the Ohio Locomotive Crane Co.

In the July 27 issue in the table of principal equipment accompanying the article entitled "New Morrison Hotel Plant —II" it is stated that the three closed heaters were furnished by the Alberger Condenser Co. As a matter of fact they were from the Alberger Heater Co.

The **Weight of Steam** for blowing a producer or furnace is determined from a gage, which should be carefully calibrated before and after the test, and connected near the steam nozzle, by Napier's formula for the flow of steam through nozzles:

$$W = \frac{P \times a}{70}$$

Where

W = Weight of steam per second;
P = Pressure in pounds absolute;
a = Area of nozzle in square inches;
70 = A constant for all pressures above 25 lb. absolute.

Rotary Valveless Air-Pump*

There are many pumps described as rotary that are really disguised reciprocating pumps. The Globe-Johnston is truly a rotary pump and is truly valveless. It is manufactured by the Globe Pneumatic Engineering Co., Ltd., of London, England. The essential parts of the pump are the rotor shown at A and the drum shown at B in Fig. 1. The casing C protects the pump from dirt and shields the rotating drum. The rotor is built up of a spider carrying an outer ring with a deep double screw thread on its circumference. Over half the length of the rotor surface the thread is right-handed and over the other half left-handed, thus eliminating end thrust. Various scrolls of the thread are joined by cross-partitions K, Fig. 1, which extend in from the circumference about half the depth of the thread. The rotor is fast to a shaft made in two parts and coupled together through the center. The left-hand shaft is hollow and is used as part of the suction pipe. The rotor is carried on ball bearings mounted on inner bosses, which are part of the frame D. The drum B is practically a plain cylinder with closed ends, and is also mounted on ball bearings. The drum, however, is not concentric with the rotor, the center of its ball bearings being set lower.

Water is run into the drum through the pipe D until it stands at the level of the bottom of the hole in the guard ring E. The water cannot stand higher than this, for if more were run in it would simply run out into the bottom of the casing C. As the rotor moves round, the water is carried along, partly by surface friction and partly by the cross-partitions between the threads. The drum, which is free to

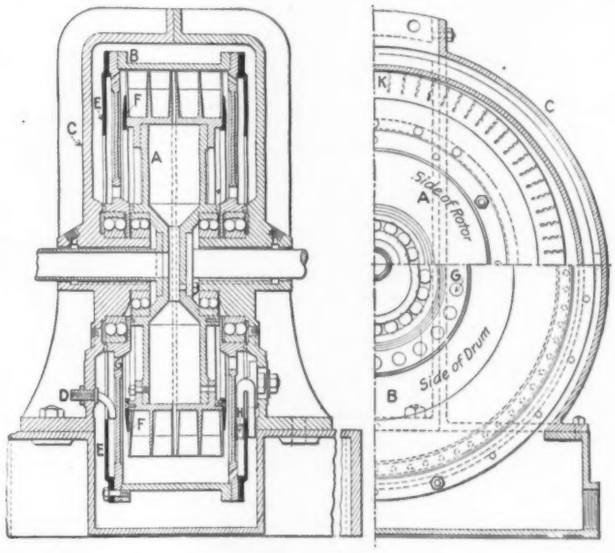


FIG. 1. LONGITUDINAL AND END SECTIONS OF VALVELESS AIR-PUMP

rotate, also begins to move because of the friction of the water on its inner surface. As the rotor and drum thus rotate together, the water is carried with them, and, by its centrifugal force, distributes itself at a uniform depth all around the inside of the drum. In a quarter of a minute or so the whole action has taken place and the two parts are rotating together with a cylinder of water between them.

The pumping is caused by the action of the screw thread on the rotor and by the rotor and drum being set out of center from each other. As the rotor moves around, the screw thread on its circumference continually dips deeper into the surrounding cylinder of water at the top and lifts partly out of the water at the bottom position. There is a continual rise and fall of the water between the threads of the rotor. This tide causes the pumping action. The air is drawn through the hollow shaft and through the space in the center of the rotor spider to the circumference of the rotor between the right-hand and left-hand threads. At the bottom of the rotor the tide is low and communication is established around the end of the inner threads between the suction and the space between the threads. The rotor moving around dips deeper into the water, and this connection is severed. The rise of the water cuts off the communication between the suction and

*Abstracted from "Engineering," of London.

the passage between the threads, thus isolating the air in the passage. As the rotor continues to move around, this air is driven forward between the threads by the rise of the water continually decreasing the volume of the passage. The trapped air thus forced along is discharged at the end of the rotor. It begins to leave the rotor at the point where the outer edge of the ring F leaves the water. At this point communication is established from the passage between the threads to the inside of the drum, and from there the air escapes into the casing through the holes G.

The discharge action will be better understood from the view of the rotor in Fig. 2, where the ring F is well shown. Toward the top this ring dips into the water so that there is no connection from the passage between the threads to the inside of the drum. Toward the bottom of the rotor, however, where this ring leaves the water, the air escapes around the end of the last thread and passes to the exhaust. The rotor is double-threaded, so that there are two discharges per revolution. Air enters at the center, passes radially to the circumference, then axially in both directions and is

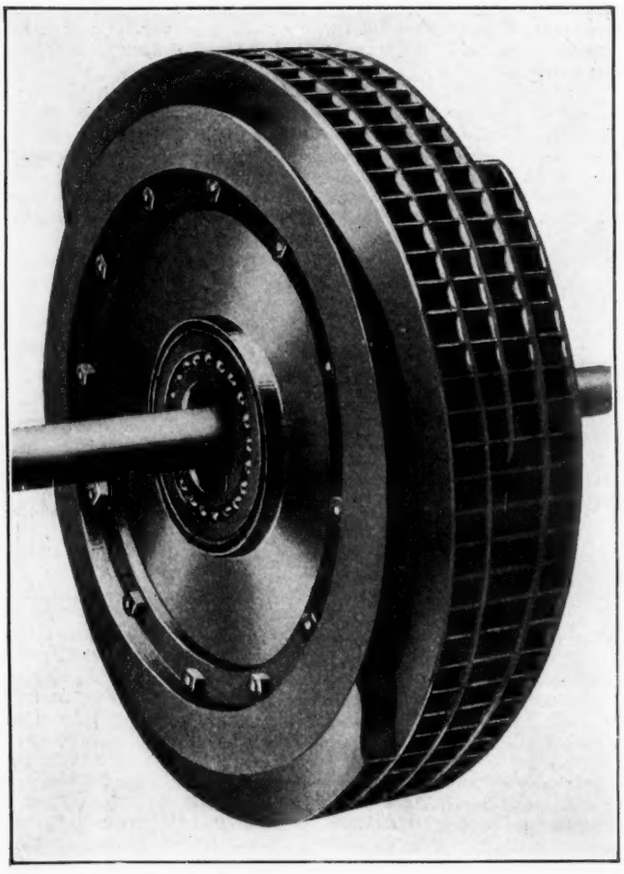


FIG. 2. PUMP ROTOR, SHOWING THE THREAD CONSTRUCTION

discharged at both sides of the rotor. In this arrangement the rotation of the drum and the water has nothing to do with the pumping action. The pump would work equally well if the water were standing still, if such a thing were possible. The rotation of the drum is, of course, necessary to maintain the water ring, and, incidentally, has an important advantage in eliminating friction. Neither the rotor nor the drum moves relatively to the water in the direction of rotation, so that there is practically no liquid friction at all. There is a small amount of friction caused by the rise or fall of water relative to the rotor threads, and possibly a little owing to the slip of the drum. This slip is probably small, and is caused by bearing resistance and by a windage effect tending to make the drum lag behind the rotor. Since the water is merely a seal, there will be none used except such as is carried off by evaporation with the pumped air. The drum may be filled to the correct height and left alone for a long time. If the water level falls, the capacity of the pump will decrease, and therefore arrangements may be made so that the water continually enters by the pipe D and is extracted by the scoop H. This maintains a constant depth of water ring.

By reversing the pump it will act as a pressure pump, and it is proposed to employ it for air compressors and similar work. When the pump is thus used the water ring must maintain the pressure of the receiver; otherwise the water would be forced out of the drum over the guard ring E into the casing. This pressure must be maintained by centrifugal force, and consequently the higher the pressure, the greater must be the speed of revolution.

Hydro-Electric Project to Be Administration Measure

President Wilson has approved the War Department's plans for a big hydro-electric plant on the Potomac River to furnish light and power for the Government buildings of the national capital. It is anticipated by many engineers and public officials familiar with the facts that the electrical development will be sufficient also to supply the commercial and domestic power and lighting needs of the city, and that municipalization of the transportation and lighting system of Washington will follow closely on the heels of the completion of the power plant.

Congress will be asked in the early hours of the coming session to appropriate $15,000,000 for the power project and to make from $1,000,000 to $3,000,000 of this amount available for immediately beginning the work. The long-discussed scheme for harnessing the vast powers now flowing to waste in the Potomac River at and below Great Falls seems certain of realization within the near future.

As a part of the project which has received White House approval there is to be constructed on the Potomac an immense reservoir which will store sufficient water for power purposes and also furnish the city with all the water it is expected will be needed during the next century. Of the total estimated cost of the project $6,000,000 is to be charged to augmentation of the water supply and $9,000,000 to power development.

Aside from the expected economy in local government the power project is intended to be a Government example to the rest of the country in government ownership of utilities, and especially of the value of the nation's unutilized water powers.

It is estimated that the maintenance cost of the big power plant, after installation, will be something more than $200,000 a year. The current developed will vary from 15,000 to 100,000 hp., depending on the flow of the stream; and taking into consideration the expected use of the big Government steam plant as an auxiliary, it is estimated that the cost of generating current at the power house will be 3.1 mills per kw.-hr., excluding interest and sinking-fund charges, or 8.7 mills per kw.-hr. with interest, depreciation and sinking-fund charges included.

The big Potomac plant is to be constructed in substantial accord with the plans made by Lieut.-Col. W. C. Langfitt, of the Board of Engineers of the Army. These plans were made following a survey provided for by Congress several years ago. Clemens Herschel, of New York, and a number of District of Columbia officials and engineers assisted in this survey and in the preparation of the plans which have received the approval of the War Department.

To obtain the necessary head of water for power purposes it is proposed to build a dam across the Potomac a few miles above Washington. From this point to Great Falls, 15 mi. above, the river flows between high cliffs and palisades, and the construction of the proposed dam will convert the stream and adjacent country into a lake from 10 to 12 mi. long. The elevation of the water surface created in this way will be 115 ft. above low water in the river at the dam.

In a statement just issued by the War Department on the subject of Colonel Langfitt's report and plans it is said:

The studies made in connection with the investigation indicate that the present average daily amount of power which must be available to safely meet the expected daily demands, is about 8000 kw., with a maximum between 3 and 6 p.m. of 11,000 kw. It is estimated that by 1937 the corresponding figures will be 17,300 kw. and 26,000 kw.

On account of the losses which may be expected in generation and transmission, it is also estimated that the delivery at the switchboards of the consumers of 26,000 kw. will require about 47,000 hp. at the turbine shafts. In dry years any deficiency in the water power will be met by the operation of steam auxiliaries already in place. The steam plant lighting the Capitol, the Congressional Library and the Senate and House office buildings has a capacity of over 10,000 hp., and can supply all deficiencies in power for a long period.

Colonel Langfitt states that he regards the combined water-supply and power-plant project which he proposes as beyond question the most satisfactory solution for Government purposes of any suggested; that the expenditure of $15,021,600, with an estimated total annual cost of operation and maintenance of $215,000, will obtain a safe and sure water supply capable of indefinite expansion as needed at very small cost, and that it will also furnish a power plant which, from the

savings effected, will return its cost within a reasonable period and also provide interest at 2 per cent.

In addition, the project will furnish opportunity for revenue from the sale of power under favorable conditions, the water power being created entirely by the general Government, and the means thereof lying wholly within its domain. It should be noted that these results are obtained on the consumption estimated at the time of the completion of the plant, and that as the consumption increases, as it undoubtedly will, the corresponding savings will be increased.

Colburn-Clark Boiler Explosion Theory Confirmed*

The first satisfactory hypothesis of the mechanism of a boiler explosion was published by Zerah Colburn in 1860, though it is supposed that the idea originated with D. K. Clark. This view supposes that the average explosion[1], "although seemingly instantaneous, may actually be a succession of operations, three or four at least, as the following:

"1. The initial rupture under a pressure which may be, and probably often is, the regular working pressure; or it may be an accidentally produced higher pressure, the break taking place in or so near the steam space that an immediate and extremely rapid discharge of steam and water may occur.

"2. A consequent reduction of pressure in the boiler, and so rapid that it may become considerable before the inertia of the mass of water will permit its movement.

"3. The sudden formation of steam in great quantity within the water and the precipitation of heavy masses of water, with this steam, toward the opening, impinging upon adjacent parts of the boiler and breaking it open, causing large openings or extended rents, and often shattering the whole structure into numerous pieces.

"4. The completion of the vaporization of the now liberated mass of water to such an extent as the reduction of the temperature may permit, and the expansion of the steam so formed, projecting the detached parts to distances depending on the extent and velocity of this action.

"This series of phenomena may evidently be the accompaniment of any explosion to whatever cause the initial rupture may be due. . . . A local defect well below the water line would simply act as a safety valve, discharging the contents of the boiler without explosion."

While it is of course true that any such picture of what happens in an explosion is artificial and speculative, still the experience of more than half a century has so largely con-

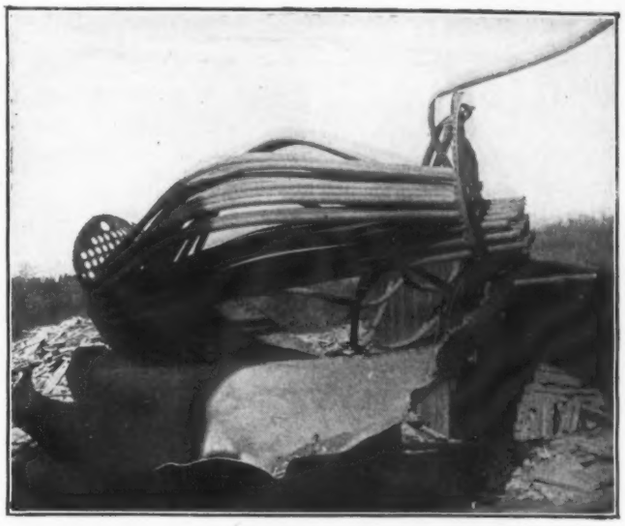


FIG. 1. THE EXPLODED BOILER

FIG. 2. AFTER THE EXPLOSION OF ONE BOILER AT ARRINGTON, VA.

*From "The Locomotive," April, 1915.

[1]Quoted from "Steam Boiler Explosions" Thurston: pp. 51 and 52.

firmed it that it remains today by far the most probable of all the theories.

Every now and then the circumstances attending an explosion are of such a nature that they permit us to reconstruct by inductive reasoning some portion of the rapid succession of events. Such a case occurred recently in the explosion of a boiler at a soapstone quarry at Arrington, Va. In accordance with the Colburn-Clark theory, a rupture below the water line need not be attended with violent results, while if the rupture is below but near it, it should be possible for both sorts of action to take place—first an outflow of water without violent disruption of the boiler until the water line is lowered to the immediate neighborhood of the break, followed by a violent explosion when that point is reached. This possibility is in no way at variance with that type of explosion where a large rupture takes place well below the water line in, say, a vertical boiler, and the reaction of the issuing jet of steam and water is so great that it lifts the boiler bodily, projecting it to a considerable distance, exactly as the issuing stream of water or steam propels a turbine wheel, or the issuing gases propel a skyrocket, for in the latter case the explosion is not violent in the sense that the boiler is torn and disrupted as if by a blow, but is only the natural consequence of the powerful jet action following a very rapid outflow below the water line.

It so happened that the boiler which exploded at Arrington was of the horizontal return tubular type made of two sheets, a single top and bottom sheet. This necessitated two continuous longitudinal seams the length of the boiler located at approximately the horizontal diameter of the heads. These seams were of lap-riveted construction. So it will be seen that the longitudinal seams were located below the water line, and indeed below the upper rows of tubes. The appearance of the boiler after the explosion indicated that the initial rupture took place at a seam crack in one of the longitudinal seams, of the type familiarly associated with the lap-riveted construction.

At the time of the explosion one of the employees of the plant was in front of the boiler which failed. Fortunately, though seriously injured, he was not killed. His story furnishes the clue to what must have taken place. He says that prior to the actual explosion came a dull roar, and streams of water poured out of the furnace and ashpit. He seems to have started for safety when a second and much more violent disturbance took place, after which he was overtaken by falling debris under a wagon where he had plunged for safety.

Assuming the substantial accuracy of his statement, this accident furnishes an almost absolute substantiation of the details of the theory which we have just set forth—that the lap crack, which had no doubt been a long time forming, finally reached such a length and depth that the seam could no longer sustain the ordinary stresses due to the working pressure. A rupture followed through which water flowed with comparative quietness until the level came down to that of the crack; then followed the rapid outflow of steam and the sudden destructive "water-hammer" action described in the paragraphs quoted above, with the violent disruption of the boiler. The violence of this particular explosion, coming as it did from a rupture below the normal water line, was undoubtedly due to the large volume of hot water, and hence available heat energy still remaining in the boiler when the second stage of the explosion arrived.

Otherwise the accident, while destructive, presented no unusual features. One man who was between the exploded boiler and an adjoining one was killed, and the plant was seriously damaged, as indicated in Fig. 2.

Recent Court Decisions

Digested by A. L. H. STREET

Duty to Inspect Machinery—The owners of a steam vessel cannot avoid liability for collision with another vessel on the ground that a bolt in the reversing machinery broke, when it appears that there had been a negligent failure for six years to inspect the machinery to discover such defects. (United States Circuit Court of Appeals, Fifth Circuit; The J. N. Gilbert; 222 "Federal Reporter," 37.)

Scope of Compensation Acts—Under the Michigan Workmen's Compensation Act, which provides for awards for injury to or death of an employee arising out of and in the course of his employment, an award cannot be made for death of a stationary engineer in an elevator accident while operating the elevator as a personal favor to coëmployees, his employment being restricted to the operation of an engine and dynamo in the basement of the building. (Michigan Supreme Court, Spooner vs. Detroit Saturday Night Co., 153 Northwestern Reporter, 651.)

Communication of Fire—The duty of an operator of a steam engine to avoid communicating fire to nearby property is to exercise a reasonable degree of care, according to the holding of the Maryland Court of Appeals in the case of Hodges vs. Baltimore Engine Co., 94 Atlantic Reporter, 1040. "What constitutes ordinary care in cases of this character," says the court, "depends upon the circumstances of the particular case. The greater the danger of communicating fire to the property of others, the more precautions and the greater vigilance will be necessary in order to measure up to the requirements of ordinary care."

Rights Concerning Dams—In a lawsuit involving rights concerning a dam in the Black River at Watertown, N. Y., the Appellate Division of the New York Supreme Court decided the following, among other, points of law:

In order that an owner of a dam may acquire a right, without an express grant, to divert the waters of a New York stream, by the maintenance of the dam, the diversion must continue for twenty years.

One who purchases land to which a dam has become affixed, in such manner as to be a part of the real estate, acquires ownership of the dam.

Where the owner of one bank of a stream constructs a dam which rests upon the other bank, not owned by him, the act constitutes a trespass upon the other land, for which the adjoining owner may maintain suit. But if a purchaser of such other land makes use of the dam, he thereby precludes himself from afterward maintaining suit on the theory of trespass. (Knowlton Bros. vs. New York Air Brake Co., 154 New York Supplement, 675.)

OBITUARY

John H. Warder died Aug. 30, at Chicago. He was born at Cincinnati, Ohio, Jan. 21, 1846. After graduating in the course of mechanical engineering at the Polytechnic College of Philadelphia in 1867, Mr. Warder became connected with the Cincinnati Southern Railway system and later with the Phœnix Iron Works for which he inspected a great many bridges. He laid out a number of power and electric plants in the City of Chicago, was in the bridge department of the Chicago, Milwaukee & St. Paul Ry., and in 1893 planned the water-works for West Pullman. Later he had charge of the construction of new sewers for the City of Chicago in Lakeview and on the northwest side and since 1901 had served as the secretary of the Western Society of Engineers. His services were of inestimable value to the society, and he will be sadly missed, not only by the membership, but by a wide acquaintance in the engineering fraternity.

PERSONALS

B. J. Morrison, general manager of the National Supply & Equipment Co., of Philadelphia, has left for Europe on a three to five months' business trip.

Richard T. Childs, for the past six years manager of the contract-news department of "Engineering News" and latterly manager of the business-news department of the Hill Publishing Co. serving the rest of the Hill Engineering Weeklies as well, has resigned, to the regret of his associates, to engage in the real-estate development business.

Max Hebgen, vice-president and general manager of the Montana Power Co., with headquarters at Butte, died at the Presbyterian Hospital, Chicago, Aug. 24, after a long illness. Mr. Hebgen was prominent in the electrical industry, and was closely associated with H. M. Byllesby in the formation of what has become the Montana Power Co., one of the large hydro-electric systems of the United States.

Van H. Manning, of Holly Springs, Miss., has been appointed by President Wilson to be director of the Bureau of Mines. The appointment is to fill a vacancy caused by the death of Dr. J. A. Holmes. Mr. Manning has been in the Geological Survey for many years. He was appointed to the Bureau of Mines when it was created in 1910, and was made assistant director in the following year. Since June 1, when Dr. Holmes was forced by failing health to suspend work, Mr. Manning has been in charge of the Bureau. He has been identified with mine rescue work, mine-sanitation projects, and a variety of mining and metallurgical problems.

ENGINEERING AFFAIRS

The American Society of Heating and Ventilating Engineers has decided to hold its summer meeting Sept. 16 and 17 at Atlantic City. This meeting was formerly scheduled for San Francisco.

The National Association of Cotton Manufacturers will hold its semiannual meeting Sept. 9 to 11 at the Hotel Griswold, near New London, Conn. Among the papers to be presented are: "Cooling Ponds for Condensing Engines," "Ball Bearings for Cotton Mills" and "Prevention of Accidents in Cotton Mills." C. J. H. Woodbury, 45 Milk St., Boston, Mass., is the secretary.

The National Exposition of Chemical Industries will be held at the Grand Central Palace, New York City, during the week beginning Sept. 20. This is the first American exposition of chemical industries, and it is expected to include exhibits of coal, wood, and petroleum products, metals, minerals, water and sewage purification, air and gas processes, glass and ceramics, oils, varnishes, plastic rubber, leather and glue.

The Polytechnic Institute of Brooklyn has announced for the season of 1915-16 a series of evening and Saturday afternoon courses in engineering, chemistry, physics, mathematics, drawing, history, economics and languages. These courses are designed to afford men in the active practice of civil, electrical, mechanical and chemical engineering opportunities for professional study. The work begins on Monday, Oct. 4, but those contemplating entrance are requested to register before Oct. 1 with the director, Prof. Charles A. Green

The Association of Iron and Steel Electrical Engineers will hold its ninth annual convention Sept. 8 to 11 at the Hotel Statler, Detroit, Mich. Among the papers presented will be "Improving Noncondensing Power Plant by Use of Direct-Current Mixed-Pressure Turbine Equipment," by R. F. Patterson; "The Electrification of Steel Mills and the Use of Central Station Power," by Brent Wiley and Wilfred Sykes; "Purchased Power for Steel Mills," by C. S. Lankton, and "Installation of Electrical Equipment to Comply with Requirements of Safety," by Walter Greenwood. A joint session will be held with the American Institute of Electrical Engineers, at which papers will be given on "Recent Developments in Power Generating Apparatus," by P. M. Lincoln; "Protection and Control of Industrial Electric Power," by Charles P. Steinmetz; "Motor Generators vs. Rotary Convertors," by E. Friedlaender; "Some of the Latest Developments in Electrical Equipment," by K. A. Pauly, and "Mechanical Analogies in Electricity and Magnetism," by Prof. W. S. Franklin. Alfred H. Swartz, 10704 Churchill Ave., Cleveland, Ohio, is chairman of the convention committee.

Panama-Pacific Conventions will be held in San Francisco Sept. 16 to 18 by the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Society of Civil Engineers, and the American Institute of Mining Engineers. The International Engineering Congress, which has been organized by these four societies and by the Society of Naval Architects and Marine Engineers, will be held from Sept. 20 to 25. A comprehensive program of technical sessions, inspection trips and other interesting features has been arranged for the benefit of those attending this general gathering of the engineering profession. A special train will leave New York on Sept. 9 arriving in San Francisco on Sept. 15, with stopovers at Niagara Falls, Colorado Springs and the Grand Cañon. A special train will also leave New Orleans on Sept. 12, arriving at San Francisco on Sept. 15. There will be no return special train service, but a choice of several routes is offered. Representative Canadian committees of the British Institution of Civil Engineers, the Canadian Society of Civil Engineers and the American Society of Civil Engineers have invited those attending the congress to return through Canada, inspecting en route the engineering works within convenient distance of the main line of transportation through the provinces of British Columbia and Alberta. The installations visited will include the water-power development of the British Columbia Electric Railway Co., the Western Canada Power Co., the Calgary Power Co. and a number of large irrigation projects in Alberta.

The general sessions of the Congress are to be held in the Auditorium Building. The opening session will be held Monday, Sept. 20, at 10 a.m., at which an address of welcome will be made by the mayor of San Francisco. General Goethals, honorary president of the Congress, will then address the convention, and the John Fritz medal will be presented to Dr. James Douglas, past-president and honorary member of the American Institute of Mining Engineers. Papers will be presented by eminent engineers from all over the world at the following sectional and parallel sessions: Waterways; irrigation; municipal engineering; railway engineering; materials of engineering construction; mechanical engineering; electrical engineering; mining engineering; metallurgy, naval architecture and marine engineering and miscellaneous. Of particular interest to the power-plant industry will be the sessions of the mechanical engineering section, at which papers will be presented on "Power Plant Design," by H. S. Putnam, New York; "The Internal-Combustion Engine of the Year 1915," by Prof. Charles Lucke, Columbia University; "The Development of the Construction of Turbines in the Netherlands," by D. Dresden, Hengelo, The Netherlands; "The 1915 Steam Turbine," by E. A. Forsberg, Stockholm, Sweden; "The Diesel Engine in America," by Max Rotter, chief engineer, Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo.; "The Boiler of 1915," by Arthur D. Pratt, Babcock & Wilcox Co., New York; "Compressed Air in the Arts and Industries," by W. L. Saunders, president of the American Institute of Mining Engineers and of the Ingersoll-Rand Co., New York; "Equipment Processes and Methods for Boiler Shops," by E. P. Meier, Phœnixville, Penn. Among the papers to be presented before the electrical-engineering section are: "Economics of the Electric Power Station Design," by H. F. Parshall, London, England; "The Water Power of Sweden," by Sven Lübeck, Stockholm, Sweden; "Electric Power in Canadian Industry," by Charles H. Mitchell, Toronto, Canada; "Industrial Effect of Low Cost of Electric Energy," by L. H. Ferguson, Chicago; "The Effect of Hydro-Electric Power Transmission upon Economic and Social Conditions with Special Reference to the United States of America," by Frank G. Baum, San Francisco. Papers will also be given on refrigeration, by J. S. Nickerson, Chicago, Thor Anderson, Stockholm, Sweden and by L. Marchis, Paris, France. An introductory paper on heating and ventilation will be delivered by Prof. R. C. Carpenter, Ithaca, N. Y. D. D. Kimball, New York, will give a paper on "Recent Developments in Heating and Ventilation Art," and Prof. James D. Hoffman, Lincoln, Neb., will speak on "Vacuum, Vacuo-vapor and Atmospheric Heating Systems."

NEW PUBLICATIONS

PRACTICAL MECHANICS AND ALLIED SUBJECTS. By Joseph W. L. Hale, associate professor of engineering, The Pennsylvania State College. Published by McGraw-Hill Book Co., Inc., New York. Cloth, 229 pp., 4½x7 in.; 201 illustrations. Price, $1.

This book contains a large number of practical problems (without answers), which are accompanied by brief explanations of such parts of mechanics as forces, specific gravity, levers, screws, gears and elementary machines. The sections on "Allied Subjects" seem to relate to heat, logarithms, measurement of right and oblique triangles, electricity and strength of materials. The treatment is hardly complete enough for individual study, but no doubt would be satisfactory for teaching purposes in trade and vocational schools.

INTERNAL COMBUSTION ENGINES. By Robert L. Streeter, Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute. Published by McGraw-Hill Book Co., New York, 1915. Size, 6x9½ in.; 418 pages; illustrated. Price, $4 net.

This is somewhat more than a text-book, for in addition to the usual historical review, thermodynamic principles and descriptive matter, about one-third of the book is given up to features of design. Moreover, the author does not hesitate to point out the relative merits of different designs. The descriptive matter is especially complete and includes representative types of gas and oil engines. Particularly instructive is the chapter on the Humphrey pump. More data might have been given profitably on engine performance, as well as operating information. Nevertheless, engineers interested in internal-combustion engines will find the work useful as a reference.

TEST METHODS FOR STEAM POWER PLANTS—By Edward H. Tenney. Published by D. Van Nostrand Co., New York. Red leather flexible binding; 224 pages, 5x7½ inches; 85 illustrations. Price, $2.50.

The field covered by this book may be judged from the chapter headings, which are: "The Purchase and Testing of Coal," "Investigation of the Economy of Combustion," "Treating and Testing Water for Boiler-Feed Purposes," "Evaporative Tests for Capacity and Efficiency," "Methods of Testing Prime Movers," "Testing of Power Plant Lubricants." The chapters relating to the testing of coal, flue gases, feed water and lubricants are especially valuable. They contain a brief

description of the apparatus required, the methods of conducting tests and of calculating the results. The conclusions that should be drawn from the tests are also indicated. While the testing of boilers, steam engines and steam turbines is considered, the treatment of these subjects is neither as complete nor as satisfactory as is that dealing with materials commonly tested in the power plant. The value of the book would have been increased if a chapter had been added on complete plant tests. At the end of each chapter is a carefully selected list of references to related articles. The book should prove useful to those interested in power-plant chemistry.

GAS, GASOLINE AND OIL ENGINES. By G. D. Hiscox and V. W. Page. Published by the Norman W. Henley Publishing Co., New York. Size, 6x9 in.; 640 pages; illustrated. Price, $2.50 net.

This is the twenty-first edition of Mr. Hiscox's well-known book, the work of revising, enlarging and bringing it up to date having been accomplished by Mr. Page, whose familiarity with automobile practice is reflected in an excellent chapter on this subject.

The book is an attempt to cover the whole field of gas, gasoline and oil engines; and while space limitations have made it necessary to touch only the high points in some cases, the authors have succeeded well in their purpose, for the information contained should meet the requirements of all save the specialist. The text matter, following a simple explanation of the cycles and the essential thermodynamics, takes up fuels, mixing valves and carburetors, governing, ignition systems, engine cooling and lubrication, engine testing, stationary and marine gas and oil engine types, Diesel engines, farm engines, automobile and aëroplane motors, piston speeds, valve timing, producers, blast-furnace and coke-oven gas. While more attention has been paid to the small- and medium-sized engines, descriptive matter is included relative to some large gas engines and Diesel motors. An especially instructive chapter is that on gas-engine management. The illustrations are good and care has been taken to proportion them properly.

TECHNICAL PAPER ON NATURAL GASES

The United States Bureau of Mines has issued Technical Paper No. 109, dealing with the chemical and physical properties of the natural gases used in 25 cities in the United States. The paper is written by G. A. Burrell and G. G. Oberfell and contains the first comparative data of this kind published. Copies may be obtained from the Bureau of Mines, Washington, D. C.

TESTING OF RUBBER GOODS

The Bureau of Standards' Bulletin 38, now issued in the third edition, gives an illustrated and detailed description of the procedure in conducting physical and chemical tests of rubber. The subject matter is introduced by a brief outline of the processes from crude rubber to the finished product and by a general discussion of the chemistry of rubber. Copies may be obtained from the Bureau of Standards, Washington, D. C.

STANDARDIZATION OF BOMB CALORIMETERS

Circular No. 11, "Standardization of Bomb Calorimeters," has just been issued by the Bureau of Standards. The paper describes briefly the methods of calibrating bomb calorimeters and of using them to determine the amount of heat available from a given weight of coal, coke or other combustible. Provision is made by the Bureau for standardizing such calorimeters by standard samples of sugar, naphthalene and benzoic acid. These samples are sent all over the United States and make it possible to get comparable results from tests made anywhere in the country. Copies of the paper may be obtained upon application to the Bureau of Standards, Washington, D. C.

LOW-TEMPERATURE COKE AND ITS PRODUCTS

The Engineering Experiment Station of the University of Illinois has issued Bulletin 79, entitled "The Coking of Coal at Low Temperatures With Special Reference to the Properties and Combustion of the Products," by S. W. Parr and H. L. Olin. The bulletin presents the results of studies made in continuation of the work described in Bulletin 60. These results show that the coke, tar and gas have specific properties of value and indicate that the process of coking at low temperatures could be established successfully on a commercial basis. The coke retains no tar-forming constituents and may be used in the suction gas producer. It is likewise adapted for domestic appliances when absence of smoke and soot is desirable. Copies of the bulletin may be obtained gratis from C. R. Richards, University of Illinois, Urbana, Ill.

BOOKS RECEIVED

PRACTICAL MECHANICS AND ALLIED SUBJECTS. By Jos. W. L. Hale. McGraw-Hill Book Co., Inc., New York. Cloth; 224 pages, 4½x7 in.; 201 illustrations; tables. Price, $1.

THE SLIDE RULE. By Charles N. Pickworth. D. Van Nostrand Co., New York. 13th edition. Cloth; 123 pages, 5x7¼ in.; 37 illustrations. Price, $1.

INTERNAL COMBUSTION ENGINES. By Robert L. Streeter. McGraw-Hill Book Co., New York. Cloth; 418 pages; 6¼x9½ in.; 240 illustrations. Price $4.

ENGINEERING THERMODYNAMICS. By Charles E. Lucke and John J. Flather. McGraw-Hill Book Co., New York. Cloth; 688 pages; 6¼x9½ in.; 189 illustrations; tables. Price $5.

HANDBOOK OF THERMODYNAMIC TABLES AND DIAGRAMS. By Charles E. Lucke. McGraw-Hill Book Co., New York. 238 pages; 6¼x9¼ in.; 82 illustrations; tables. Price $1.50.

COMBUSTION AND SMOKELESS FURNACES. By Jos. W. Hays. G. L. Simonds & Co., Chicago, Ill. Cloth; 118 pages, 6¼x9¼ in.; illustrated. Price, $2.

ELECTRICAL MEASUREMENTS AND METER TESTING. By David Penn Moreton. Frederick J. Drake & Co., Chicago, Ill. Cloth; 328 pages, 4¼x6¾ in.; 191 illustrations; tables. Price, $1.

VALVES AND VALVE GEARS, Vol II. By Franklin DeRonde Furman. John Wiley & Sons, Inc., New York. Cloth; 190 pages, 6x9¼ in.; 170 illustrations. Price, $2.

PROPERTIES OF STEAM AND AMMONIA. By G. A. Goodenough. John Wiley & Sons, Inc., New York. Cloth; 108 pages, 6¾x10¼ in.; illustrated; 79 pages of tables. Price, $1.25.

TRADE CATALOGS

Lea-Courtenay Co., Newark, N. J. Catalog H-2. Centrifugal pumps. Illustrated, 64 pp., 6x9 in.

Coppus Engineering & Equipment Co., Worcester, Mass. Catalog. Coppus turbo blower. Illustrated, 40 pp., 5½x9 in.

Cutler-Hammer Mfg. Co., Milwaukee, Wis. Loose Leaf Catalog. Electric controlling devices. Illustrated, 4½x8 in.

L. W. Randolph, Inc., 9-15 Clinton St., Newark, N. J. Catalog. Tygard rotary steam engine. Illustrated, 30 pp., 4½x6 in.

Templeton, Kenly & Co., Ltd., 1020 S. Central Ave., Chicago, Ill. Bulletin Catalog No. 115. Simplex jacks. Illustrated, 24 pp., 6x9 in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 130. Lubrication of Pneumatic Tools. Illustrated, 8 pp., 6x9 in.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1093. Engine-type direct-current machines. Illustrated, 16 pp., 8x10½ in.

Emerson Pump & Valve Co., Alexandria, Va. Catalog. Steam pumps, foot valve and quick-cleaning strainer. Illustrated, 80 pp., 6x9 in.

Burd High Compression Ring Co., Rockford, Ill. Directory of piston ring sizes for automobiles, trucks, tractors, engines. Illustrated, 134 pp., 4½x7 in.

BUSINESS ITEMS

The Kansas Gas & Electric Co. is reported to have purchased the Arkansas City Water-Power Co. and the Arkansas City Gas & Electric Co., capitalized at $50,000 and $100,000 respectively. The purchase consists of a canal five miles in length with the necessary dams, gates, and water-power plant having a capacity of 1500 hp., a steam plant of 1000 hp. and the electric-lighting service and equipment for Arkansas City.

When you read the headline of the Lagonda Mfg. Co.'s advertisement on the inside back cover of the Aug. 17th issue—"Lagonda Boiler Cleaning Tubes"—you may have wondered if this concern was now making a boiler that cleaned tubes. The title, however, is simply a printer's error—you know the jokes they have about queer mistakes made by printers—and should have read "Lagonda Boiler Cleaning Tools."

Link-Belt Co., Chicago, Ill., has just finished its new Link-Belt general catalog No. 110, which embraces its entire line of manufacture by description, illustration, price lists, and engineering data. Among other things it gives complete details about power-transmission machinery, including bearings, hangers, pulleys, gearing, and clutches; chains and sprocket wheels for elevators, conveyors, and drives; the Peck carrier for coal, ashes, stone, etc.; standard types of coal and ashes handling machinery and accessories; in fact it contains 576 pages of real engineering information. If you write for a copy on your business stationery it will be sent free.